ENGINEERING

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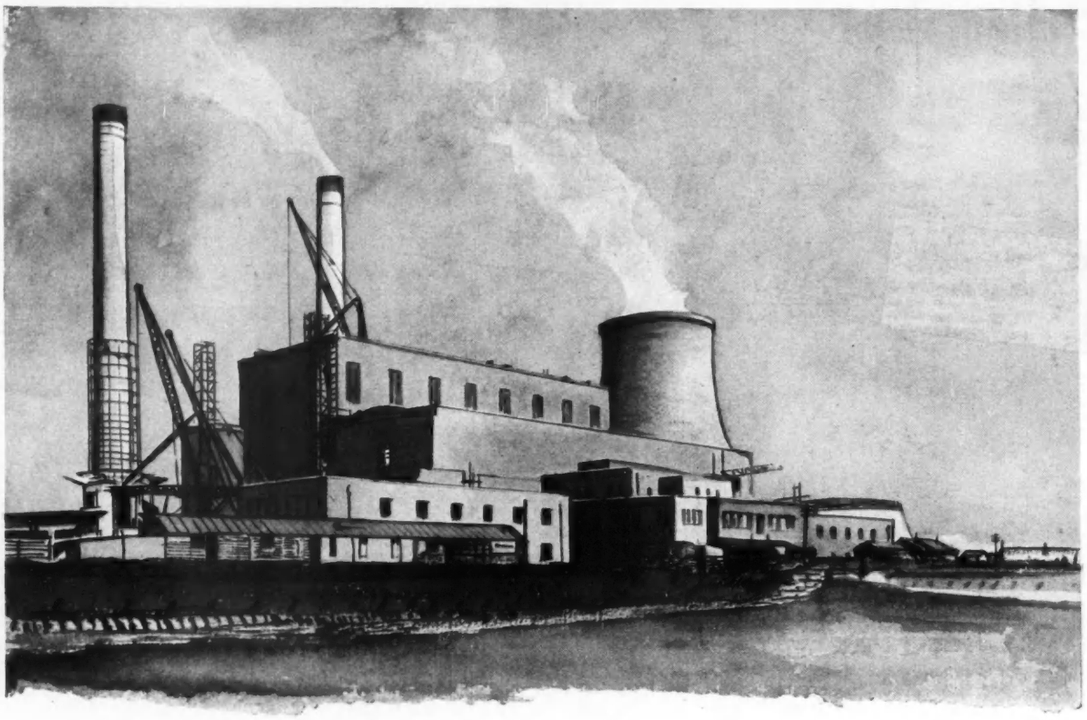
INSULATING ROTOR COILS



Lockheed remote controls at Connah's Quay Power Station

This important power station, of which the first section was opened last autumn, has a steaming capacity of 600,000 lb. per hour provided by two boilers which operate at 625 lb. per sq. in. and 865°F; ultimately there will be six boilers in the station.

All the main dampers on the two boilers now in service are remote-controlled by Lockheed hydraulic control equipment operated from the unit control panel.

Lockheed hydraulic remote controls are designed, produced and installed by a highly specialized department which undertakes the work right from the original discussion to the final smooth-working installation.

Moreover, it is backed by concentrated experience over very many years, and by an efficient service and maintenance organization.

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AUTOMOTIVE PRODUCTS COMPANY LIMITED, LEAMINGTON SPA, ENGLAND

ENGINEERING

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Vol. 179 No. 4661 MAY 27, 1955

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LOOKING FOR A JOB

At least once in every engineer's life he is faced with the problem of looking for a job. Perhaps he is on the point of completing his studies, has recently returned from an overseas appointment, or has merely decided that he wants a change. What steps can he take? If he is lucky he may receive an unexpected offer, or hear in conversation of the ideal post, but in general he will need to make a wide and cautious search. He may begin by consulting the "situations vacant" columns of the daily or technical Press, or by picking likely firms at random from a trade directory; but in some cases, particularly if he is about to leave college, he may get in touch with a professional appointments bureau.

Bodies of this kind serve as an exchange centre for information concerning both applicants and vacancies, and aim to meet the needs of both parties involved. An employer supplies details of his requirements and an applicant makes known his qualifications and preferences, so that by judicious selection from each set of records suitable recommendations can be made and interviews arranged. Neither party is committed to accept proposals made by the bureau. Among organisations of this kind are the Technical and Scientific Register of the Ministry of Labour and National Service, the university appointments boards, and the Professional Engineers Appointments Bureau. This bureau, which during 1954 received particulars of more than 9,000 engineers, covers vacancies in civil, mechanical and electrical engineering, and has connections with the three senior engineering institutions. It reports that the main demands in civil engineering have been for engineers with wide design or contracting experience and for young men prepared to accept overseas posts. Numerous requests for civil engineers have also been made by local authorities. Mechanical engineering vacancies have occurred in such fields as chemical-plant manufacture, servo-mechanisms, production, and management; while in electrical engineering experience in electronics and light-current engineering has been in demand.

Probably the largest source to-day of qualified engineers of all kinds is the university, and a valuable link between employers and engineering graduates is the university appointments board. The boards have special advantages in that contact between an applicant and an appointments secretary frequently lasts for several years and a friendly personal relationship is often established. Before being called to recommend a permanent position, the secretary, who is generally a man of wide industrial experience, has probably been responsible for placing the candidate in a number of vacation jobs, and has discussed with him his hobbies and ambitions; what is more, by consulting tutors and directors of studies, the secretary has been able to obtain an indication of the student's academic progress. He is thus well equipped to select the right applicant for a given vacancy. Graduates may return to their appointments board at any time during their careers for further guidance.

Alternatively, an engineer may make use of the Ministry of Labour's Technical and Scientific Register. This service, which is assisted by committees of the appropriate professions, keeps a record of vacancies and applicants, and acts also in an advisory capacity. During the four weeks between February 15 and March 14 of this year, 655 vacancies were notified and 163 were filled, but at the end of this period a total of 4,568, including those carried over from previous months, were still outstanding. A total of 3,607 applicants remained on the register. Many of the unsatisfied applicants lived in different parts of the country from the unfilled vacancies; in addition, employers were often looking for qualifications and experience which the applicants did not possess. If these associated problems of location and specific requirements did not arise the present shortage of technologists might be less serious. It is evident therefore that the man willing to "go anywhere, do anything" is likely to find a job sooner than his more static colleagues. Mobility and adaptability are useful qualities for the young engineer setting out on his career.

In a previous leading article we attempted to show the importance of occasional change of employment—importance for the employer and the country as for the individual. There is no doubt that, particularly in the older industries, too many men remain too long on the same kind of work (notable exceptions prove the rule). There are some, too, who move around far too frequently. But when a move is contemplated, or when new staff are required, advertisements in the daily and technical Press are the most widely used medium. They are quick, and they are direct. The Professional Engineers Appointments Bureau undoubtedly meets an important special need, but the need for the Technical and Scientific Register, maintained at public expense, is not so apparent. A few years ago a shortage of professional engineers and of technicians in Britain was forecast. That shortage is now with us. The number of draughtsmen, especially, is insufficient. The machinery for bringing employers and applicants together must work efficiently if we are to make the best use of our limited resources.

Weekly Survey

Cover Picture. *Various materials are used to insulate the turns of coils from each other in the rotors of electric motors, the materials being chosen according to the conditions of operation. Where the temperature rise is comparatively low, treated paper strips may be used. When higher rises are expected, treated asbestos or similar material is employed. The illustration shows the turns for the rotor coils of a synchronous induction motor being lowered into position one by one while the girl interleaves them with treated asbestos strips.*

* * *

CAPITAL FOR INDUSTRY

An interesting controversy was touched off last week on the question of finance for industry. This is a topic on which a certain amount of public discussion is particularly welcome at present, when the country faces a period of very high capital investment, a prospect in which the engineering industry has a vital interest. In his presidential address to the Institute of Bankers last week, Sir George Erskine, a managing director of Morgan Grenfell and Company, who are one of the leading finance houses and merchant bankers in the City of London, called upon the bankers to play a bigger role in financing industry. Sir George went so far as to suggest that the commercial banks should go to the lengths of holding shares in companies, provide long-term advances for fixed periods and extend loans to assist investors to take up new securities. In orthodox banking circles this point of view, which Sir George seems to hold in a fairly extreme form, has been considered a grave heresy until very recently.

Of recent years orthodox doctrine has, however, been significantly relaxed in one important respect. The banks have contributed capital to such important long-term financing organisations as the Industrial and Commercial Finance Corporation which was set up after the war. More recently still, several of the big joint stock banks have taken a controlling interest in hire-purchase finance companies. One way and another the supposed shortage of channels to provide capital for industry has been met to a large extent and the banks have indirectly played a very significant part in increasing them. Financiers who share Sir George's view will probably take the line that although the facilities available for enterprise are adequate for the rate of investment in, say, 1953 or 1954, they are much less adequate either in number or in size of their resources to provide an adequate flow of capital for the investment programme of the late 1950's and the 1960's.

It is timely that this issue should be raised. There is reason to doubt, however, if it is the basic problem. It may well be that in the end the problem is not so much in which direction the savings of the community should be channelled into investment as how to increase those savings. The banks have very little influence on the saving habits of companies and individuals. Such evidence as there is since the war goes to show that the best stimulant to saving is an absence of serious inflation. If this problem can be successfully handled, and no Government since the war has a particularly successful record in this respect, the question of organising the flow of savings will be much easier to solve. This does not mean, of course, that no thought need be given now to organising the flow of savings: nothing but good can come from a discussion of the question before the enormous investment commitments scheduled for the late 1950's begin to take tangible form.

* * *

I.C.I.'S RECORD

In spite of intense competition from overseas firms and organisations, the Imperial Chemical Industries group was able to increase its exports last year by 16 per cent., compared with an increase of about 3 per cent. for British exports as a whole. Total sales for the twelve months ended December last amounted to £352 million against £282 million for 1953, direct exports amounted to £67·5 million against £58 million, gross profits were £49·5 million compared with £36 million, and the net income of the parent company alone, after allowing for taxation, was £21·7 million compared with £17·6 million. The firm's annual report for 1954 discloses that a substantial increase in productivity in relation to manpower has been attained, the volume of production last year being about double that of 1946, although the increase in the number of employees over the period amounted to only 17 per cent.

Since the end of the war, the I.C.I. group has spent over £190 million on the purchase of new fixed assets. Research and development alone now require an annual expenditure of over £8 million a year. More than half of this effort is devoted to the discovery of new products and the development of improved processes. Following on two years of decline, the firm's export of pharmaceuticals was increased last year by some 5½ per cent., and, in the same period, the group's dyestuffs division also enlarged its share of the world's export trade. Last year, there was a thorough revision by the company of the estimated "working life" of its plant and equipment, as a result of which the management found that many of these assets now had to be written down in value more sharply than had hitherto been considered necessary. Higher annual depreciation charges have accordingly been introduced. A substantial capital-expenditure programme is envisaged, but the firm is provided with considerable funds. Its net liquid assets at the end of 1954 amounted to more than £51 million, against about £31 million a year previously. This improvement was due, in part, to a loan raised among the firm's own stockholders.

Referring to these achievements, Dr. Alexander Fleck, the company's chairman, stated in London last week that if every industry showed the same progress, the target of doubling this country's standard of living in 25 years could be attained in a much shorter period. He added that a large organisation, like a small one, should be judged by results rather than on the basis of political dogmas.

* * *

NATIONALISATION REJECTED

Plans referred to in the Labour Party's election manifesto for bringing sections of the chemical industry under public ownership have drawn a sharp rejoinder from Dr. Fleck. He stated at a Press conference prior to the publication, on May 19, of the I.C.I. annual report for 1954, that the firm's board of directors were determined to oppose by every proper means within their power any attempt to nationalise the company, or any part of it. In his opinion, any form of nationalisation of the company could only result in damage to its work at home and abroad, and would be harmful to British industry generally and to the country's whole economy.

Dr. Fleck, whose personal scientific achievements have been noteworthy, became chairman of I.C.I. in 1953. He suggested that in no sense could the firm properly be described as a monopoly. So far as numbers of workpeople were concerned, for example, the company represented no more than one-third of this country's chemical industry. In fact, many of its products were in direct competition with those of other organisations, either British or foreign, and often with both. In the case of products of which the company was the principal manufacturer, the same efforts were applied to improve and cheapen production as were directed to all other sections of the firm's output. He felt, too, that it should be more generally realised that ownership of the group was very widely distributed.

Good relations were maintained between the company and its employees and there had been no serious industrial dispute in the organisation since its inception in 1926. In accordance with the new profit-sharing scheme introduced last year, £2·65 million had been allocated to trustees for the employees; this amount being based on the ordinary dividend paid to the shareholders. After allowing for tax, £1·9 million would be available for the purchase of shares of the company for its workpeople.

* * *

CAMMELL LAIRD AND COMPANY

Cammell Laird's experience as shipbuilders in 1954 was very much that of the industry as a whole. Output was substantially up—72,100 tons compared with 61,750 in 1953—and some useful orders were received towards the end of the year. Due mainly to the extended delivery position—the company still have orders on hand which will keep them occupied till the end of 1957—a number of orders were lost to Continental yards. These yards, as Mr. J. C. Mather, the chairman, points out in his annual statement, have an adequate labour force to draw from and no demarcation problems. In this country bans on overtime are prevalent and even the 44-hour week is not conscientiously worked by many employees. These problems are not new. There has been plenty of exhortation from shipbuilding management, and the unions have never failed to express the best intentions, but very little has been done. It may be that many orders will still have to be lost and the prosperity of British shipbuilding undermined before a realistic attitude is precipitated. Mr. Mather considers that the demarcation issues should be tackled by the trade unions at a national level. Union action on this issue would go far to improving the competitiveness of British yards.

As builders of rolling stock, Cammell Laird achieved a record output in 1954. New export contracts gained by the Metropolitan-Cammell Carriage and Wagon Company include 200 coaches and parts for 100 more for Brazil, 94 mechanical structures for Diesel-electric locomotives for Ireland and 2,000 wagons for India. Metropolitan-Cammell, with an order for 72 Diesel railcars, were the first private contractors to receive a contract for these vehicles under the re-equipment programme of British Railways. Demand for road public-service vehicles has been less satisfactory, and the company's body-building factory (like those of other manufacturers) has been working at reduced capacity. Nevertheless, some large orders were received towards the end of the year for the company's lightweight buses, for which substantial savings in operating costs are claimed.

Cammell Laird are once more in the steel industry. Their 25 per cent. holding of the equity capital of the English Steel Corporation (Vickers Limited hold the remainder) should be the source of further strength to an already very prosperous concern.

* * *

EUROPEAN OIL EQUIPMENT

Adverse comparisons of European with American productivity are easily made and are misleading when no attempt is made to show the extent to which the differences are due to special conditions. The report of a Technical Assistance Mission of the Organisation for European Economic Co-operation on Oil Equipment in Europe is therefore all the more valuable in that it considers sympathetically the handicaps with which European manufacturers have to contend. It notes, for example, the Italian unemployment problem and the obligation of many companies to retain employees whom it is either legally or humanely impossible to discharge. The European markets for pressure vessels are never so large as to permit a manufacturer to specialise to any marked extent. Only one company finds it practical to specialise on equipment for the oil industry, but they have to manufacture a range of products wide enough to cover distilla-

tion columns, storage tanks, exchangers, etc. Too many companies are competing for the oil industry business. Manufacturers of steam locomotives and other equipment who are faced with falling demand are switching increasingly to oil equipment. With all the disadvantages, however, European makers of pressure vessels have been making considerable progress. A few years ago, their plant was far inferior to that of American manufacturers. Now, most European factories have been re-equipped and plant and processes are becoming identical, the main difference being a matter of scale. Much the same conditions apply to the manufacture of most types of oil equipment. The root cause of the European difficulties in the mission's opinion is the splitting of the market by frontiers and tariff barriers. These have fostered the growth of a disproportionate number of manufacturers, who have little incentive to maintain close contact with one another or to re-organise their output on a more rational basis.

Two main recommendations follow from this diagnosis; namely, that there should be closer contact between manufacturers and that there should be closer contact with the oil companies. It is stressed that U.S. manufacturers have found that giving publicity to a mass of important technical information of interest to the industry as a whole is not incompatible with the existence of manufacturing secrets. For maintaining contact with the oil industry the mission endorse the recommendation of a mission which visited the U.S. in 1951—that a central European council should be formed which would pursue such objectives as the publication of a catalogue on the lines of the American "Composite Catalog," and the creation of committees of experts to study the main problems in consultation with representatives of the oil companies.

* * *

OIL INDUSTRY AND ENGINE DEVELOPMENT

There is nothing small about the oil industry—particularly its capital investment. Moreover, because of rapid depreciation and heavy losses on exploration, returns have to be quick and large. According to their annual report the British Petroleum Company, Limited, spent £55 million on capital account in 1955, but depreciation amounted to £25·9 million and £4·5 million had to be written off oil exploration interests. Refinery construction programmes account for the bulk of the investment in oil. The British Petroleum Company spent £32·5 million on refineries and £17 million on transportation and marketing. Although the outlay in exploration is proportionately small, the programme is nevertheless fairly substantial, and includes considerable expenditure in Canada, Trinidad, Malta, Africa and Australia. The refinery extensions have included the commissioning of the new Aden refinery and the Kent, Hamburg and Kwinana (Western Australia) refineries. Total B.P. refinery throughput is now 24 million tons and by the end of this year should be 30 million tons.

The rate at which refinery capacity in the free world outside the American sphere has been growing is more than adequate to cover demand: whereas in 1954 capacity rose by 24 million tons, consumption rose by 18 million tons. Provided the present rate of industrial advance continues there is, however, little danger of the emergence of a surplus capacity. The main difficulty facing the oil industry is created by the relatively large increase in demand for heavier fuel oils compared with lighter fractions. Throughout the Eastern world, where consumption is generally restricted by heavy taxation, sales of motor spirit increased by about 9 per cent. in 1954 compared with 13 per cent. for black oils. The problem is intensified by the increasing use of fuel oils by electricity authorities, gas boards and railways. Pressure of demand for the middle distillate fractions has already narrowed the price between motor spirit and gas oil. A balance which will be in the best interests of users and oil industry alike will require the elimination of the artificial restrictions on the demand for the lighter fractions. The present uncertain situation can scarcely promote the soundest development in motor vehicle and industrial engines.

* * *

CHEMICAL PLANT MAKERS

As the tempo of expansion in the chemical industry rises, the work of the British Chemical Plant Manufacturers' Association on such matters of common interest as standardisation, education, market intelligence and publicity becomes increasingly important. Their annual report records progress in many directions in 1954.

In one aspect at least, progress in chemical engineering education has been less satisfactory. An O.E.E.C. report on chemical apparatus in the U.S.A. had already drawn attention to the fact that the facilities available in the United Kingdom were not properly appreciated. A survey undertaken by the Institution of Chemical Engineers on the instigation of B.C.P.M.A. and A.B.C.M. showed that while training facilities for university degrees, post-graduate diplomas and the Institution's own examinations were in constant demand, poor use was being made of courses for the Higher National Certificate. At a time when chemical engineers are in short supply, it is disappointing that more young men have not taken such courses, which are in danger of collapsing through lack of support.

On the export marketing side, B.C.P.M.A. have been able to give assistance to members on such questions as finance and credit guarantees, and commercial intelligence. The latter appears to derive mainly from foreign technical journals and from official Government overseas technical representatives. It is, perhaps, worth inquiring whether manufacturers could not combine with advantage through the B.C.P.M.A. to undertake more comprehensive and systematic market survey work. Exports of chemical plant and machinery now amount to about £9·6 million a year and opportunities are increasing. B.C.P.M.A.'s publicity role includes the staging of exhibitions. Plans have now been made for an exhibition to be organised jointly with the council of British manufacturers of petroleum equipment. Unfortunately, because of the many other important engineering exhibitions being held in 1956 and 1957, it will not be possible to arrange suitable accommodation until 1958. A specialist exhibition of this sort serves a very useful purpose although the value of trade fairs is becoming increasingly open to question. The B.C.P.M.A. report comments upon the disturbing number of new trade fairs, many of them of dubious value, mooted in all parts of the world.

* * *

ATOMIC PLANT FOR EXPORT

Sir Anthony Eden referred recently to the entirely new export trade of enormous scope which had been opened up by the advent of nuclear energy. A Weekly Survey note last week made some mention of how British makers of atomic plant and the United Kingdom Atomic Energy Authority are preparing to make the most of the new opportunities at home and abroad. Recent announcements have given further details of these plans. A new company, Nuclear Power Plant, with a capital of £1 million is to be formed under the chairmanship of Sir Claude Gibb. C. A. Parsons and Company, A. Reyrolle and Company (of both of which Sir Claude is chairman) and Head Wrightson and Company are among the companies concerned in the venture. The immediate objective is to design and build complete plants for the home market, but overseas work will be undertaken as opportunity occurs. Another group making special arrangements for atomic equipment are the English Electric Company working in collaboration with Babcock and Wilcox Limited. English Electric are to establish a new department at Whetstone, where they have taken over the premises of the National Gas Turbine Establishment. Both Babcock and Wilcox and English Electric supplied plant for Calder Hall, and staff from both companies have attended training courses at the Reactor Training School at Harwell.

The exhibitions at Geneva where the International Conference of Scientists on the Peaceful Uses of Atomic Energy is being held in August will provide an export "shop window" of considerable importance. The United States authorities are exhibiting a research reactor (of the "Swimming Pool" type) at a cost of £100,000. The cost of the exhibits of the United Kingdom (which will include models of Calder Hall) is expected to be £40,000 and there will be further expenditure by private industry.

* * *

GREAT LOCOMOTIVE ENGINEERS

At Euston Station, in the room that was formerly the Shareholders' Meeting Room, an exhibition which evokes the traditions and spirit of steam locomotive engineering is open until October 29. Models, drawings, paintings and photographs recall the work of eight great locomotive engineers. A full-scale mock-up of a modern steam engine cab can be inspected, with a driver ready to explain and answer questions. Through the "spectacle" window the visitor can watch the line-side rushing by, simulated by a cinematograph film. A pair of scissors made by Robert Stephenson during his apprenticeship is there, and at the end of the circuit of the exhibition there is a portrait of the Chief Mechanical Engineer whose locomotive still holds the world speed record, of 126 m.p.h., for steam—Sir Nigel Gresley. The portrait is several times life size—head and shoulders. Its "front elevation" appearance effectively insists that the eight engineers chosen were great.

The eight are Robert Stephenson, John Ramsbottom, Edward Fletcher, Patrick Stirling, S. W. Johnson, Dugald Drummond, G. J. Churchward and Gresley. A booklet written by Mr. O. S. Nock (British Transport Commission, 1*s*.) provides an agreeable narrative of their work, and their claims to greatness. The steam locomotive is mourned before it is dead, but no one is likely to complain: it is the patriarch of engineering.

* * *

THE COMMISSION AND THE UNIONS

The railway trade unions and the Confederation of Shipbuilding and Engineering Unions display wisdom and courage in agreeing with the British Transport Commission to establish a British Railways Productivity Council. The first term of reference is "to initiate proposals, of general concern and application, for increasing efficiency, including the best use of manpower; to advise the Commission . . . and the trade unions, as to appropriate ways and means whereby such proposals may be applied to the best advantage." Increases in wages to railwaymen during the past few years were intended to be conditional on a sincere attempt by the unions and their members to increase efficiency on the railways. But so far there has been little indication of a willingness or ability to meet that obligation. The British Railways Productivity Council may be the answer.

The Commission and the unions are equally balanced by nine members on both sides. If the work of the Council is effectively steered it should help to overcome the inertia which has retarded the progress that railwaymen and the public rightly expect. It is in the interests of the unions to see full employment maintained, because their strength is then greatest. But full employment is a condition of equilibrium that is almost unstable. Co-operation from the unions will eliminate one of the forces that can so easily upset that equilibrium. It is ironical that just when this agreement on a joint council has been reached inter-union disputes should arise as the new cause of trouble.

THE CONTROL OF FLIGHT

AUTOMATION IN THE AIR

The 43rd Wilbur Wright Memorial Lecture was given before the Royal Aeronautical Society in London on Thursday, May 19, by Dr. C. S. Draper, F.I.A.S., head of the Department of Aeronautical Engineering and director of the Instrumentation Laboratory at the Massachusetts Institute of Technology. In his lecture on "Flight Control," Dr. Draper surveyed the development of flight control before and after the Wright brothers, and showed how the basic contribution of the Wrights to successful flight was their break-away from the conception of the inherently stable machine, until then universally accepted. We give below a summary of the later part of Dr. Draper's paper in which he describes the developments in gyroscopically-controlled systems and instruments, and automatic stabilisers, that have taken place in the United States since the Wright brothers' first flights.

The Wright brothers rejected the principle that aircraft should be made inherently so stable that the human pilot would only have to steer the vehicle, playing no part in stabilisation. Instead, they deliberately made their aeroplane with negative stability and depended on the human pilot to operate movable surface controls so that the flying system—pilot and machine—would be stable. This resulted in an increase in manoeuvrability and controllability.

The Wright brothers' aeroplane that flew at Kitty Hawk had interconnection of the control surfaces about the roll and yaw axes that made the Wright machine effectively a two-control aeroplane, although in operation, moments were applied about three axes. For patent purposes, the mechanical connection of roll control with yaw control was considered a crucial point, but practical men soon discovered that giving the pilot independent controls for each of the three axes was more effective than the two-control system with roll and yaw motions interconnected.

For many years it has been a fact of common experience that human pilots can co-ordinate three-axis controls, provide stability, and also cause their craft to follow accurately flight paths that they may elect to command. In clear weather, trained human pilots and normally unstable aeroplanes form flying systems that leave little to be desired.

FLIGHT INSTRUMENTS

Once visual contact with the earth is lost, the pilot becomes helpless as a sub-system for applying corrective actions for the aeroplane controls. This unpleasant fact makes it necessary to either provide substitute earth-reference information, or restrict flying to clear weather.

In the United States, the first gyroscope instrument was the Sperry rate-of-turn indicator, built and flown in 1918. This device was intended to show turning rates with sufficient accuracy to enable the pilot to hold the direction of his aeroplane constant long enough for oscillations of the magnetic compass to settle down to a reliable reading. The rate-of-turn indicator, in combination with a curved-tube level indicator and the normal altitude, air-speed, rate-of-climb, and engine instruments, made "blind flying" possible but the margin of safety was too small for commercial operations.

In 1929 the Daniel Guggenheim Fund for Aeronautics set up a project for solving the problem of flight without visual reference to the earth. Lieutenant James H. Doolittle was given charge of this project and worked with several instrument companies to develop the gyro horizon, the directional gyro, and the sensitive altimeter. Combining these new instruments with radio localisers and radio markers, Doolittle was able, on September 24, 1929, to take off, fly a specified course, and land without any visual reference to the earth. Within fifteen years of this date, instrument flying had become a routine qualification.

Although the gyroscopic instruments actually hold directions with respect to inertial space, combinations of gyro elements with pendulous elements make it possible for the flight instruments to show the orientation of their cases (which in practice are fixed to the aeroplane) with respect to the earth. This means that the pilot's eyes looking at the indications of gyroscopic instruments provide sufficient information for him to estimate orientational corrections for the fuselage of his aircraft. In a similar way, observations of the magnetic compass give the pilot information on heading corrections. The pilot within himself generates flight control commands that he introduces as references for his estimates of orientational corrections, by making proper settings of the instruments.

In earlier flight-instrument systems, the pilot had to make separate settings for three instruments. To-day, his task is simplified by instruments like the Sperry flight director which receives a desired flight programme as its input and automatically produces outputs that are the corresponding flight commands; the pilot then operates his controls so that the indices of a "zero reader" are kept on their zero positions.

CO-ORDINATED CONTROL SYSTEMS

When the human pilot is a link in the flight control system, he must co-ordinate his three controls when he introduces stabilising corrections and also when he changes the orientation of his craft. Even qualified pilots find it difficult to achieve satisfactorily stable flight from certain aeroplanes under some conditions of operation. In such situations it is worth while to add instrumental components—e.g., yaw dampers or pitch dampers—to the control-surface drive system to co-ordinate the control action for eliminating certain aircraft instability components, without attention from the pilot. The pilot then operates his controls normally without taking any account of the instability.

Such systems would realise the pre-Wright brothers ideal of complete inherent stability for the aeroplane, with the pilot's duties limited to steering his craft, but the means that would be used are a far cry from the methods of Lilienthal, Pilcher, Chanute, and Langley. With present-day techniques the controls with which the pilot has contact do not respond in any way to the corrections required to overcome interferences from rough air and other disturbances.

NAVIGATIONAL AUTO-PILOTS

The author understands that Sir Hiram Maxim proposed gyroscopic stabilisation systems at the time of the experiments with his steam-powered aeroplane. However, no formal record of actual work on gyro stabilisers appears until a few years after the first Kitty Hawk flights.

The Sperry gyro stabiliser of 1910 consisted of a large rotor with its spin axis along the yaw axis of the aeroplane and powered by a belt drive from the engine. In action, the rotor was to resist tipping of the craft about the roll and pitch axes as a "passive" device, similar to the Schlick stabiliser for ships. Actual tests would have shown that the gyro resisted rough air interference torques about the roll axis by applying a torque about the pitch axis and vice versa. It is unlikely that the device would have been a practical solution for the automatic stabilisation problem. On the other hand, the gyro stabiliser of 1912, installed in the flying boat of Glen H. Curtiss, used gyros only to establish a substantially horizontal plane in the aeroplane and to generate signals to operate servos driving the ailerons and elevators. Provision was made for the pilot to give flight commands by using his controls to introduce signals between the geometrical references provided by the gyros and the servo control valves. Thus the system introduced the basic elements that are in all servo systems.

For about three years after 1912, the gyroscopic stabiliser benefited from a most remarkable combination of men, machines, public interest, and a favourable state of the art. The climax came on June 18, 1914, when Lawrence Sperry and the gyroscopic stabiliser, with the Curtiss Flying Boat, won a safety prize of 50,000 francs offered by the Aero Club of France for the most stable aeroplane.

In the latter part of 1915, information on automatic flight control dwindled and then ceased altogether as the veil of military secrecy descended.

After the First World War, automatic pilots were apparently neglected for something over ten years (except for some use in controlling target aeroplanes employed for anti-aircraft practice). The truth is that flight instruments and flight techniques of human pilots had to be brought up to a state where automatic flying could be fitted into a consistent state-of-the-art picture. By the early 1930's, knowledge and experiment had brought together the essentials for a substantially complete auto-pilot, and Wiley Post used the first prototype of the Sperry auto-pilot for his solo flight around the world in 1933. In this installation the gyro units were similar to the usual flight instruments. Servo power for the controls was supplied by hydraulic cylinders with valves operated by correction signals from the gyro units. Flight commands were introduced by knobs on the front of the auto-pilot box.

In a current automatic pilot system, the necessary earth geometrical reference is provided by the combination of a flight gyro for roll and pitch and a gyro flux-gate compass for yaw. A controller provides a means for introducing flight commands. Altitude control depends on an aneroid bellows with an electrical signal-generating system. Servos with follow-up potentiometers are used to apply rudder, aileron, and elevator control forces. A fourth servo is used for automatic elevator trim-tab adjustments. A yaw-rate gyro supplies signals for assistance in damping yaw oscillations. Electrical signal-generating units and electronic amplifiers are used to transmit information between components in the system. The control-surface servo-drive motors are supplied with power from magnetic amplifiers.

With the navigational auto-pilot, the pilot's only obligation is to introduce flight commands that combine with the earth reference generated by the gyro units to establish the command equilibrium orientation of the aircraft. Feedback through the rigid connections of the auto-pilot with the aircraft gives a comparison of the actual orientation correction signal. This signal contains a stabilisation component and also a flight-command component. In addition, necessary provisions for co-ordination among the three single-axis controls are designed into the auto-pilot. This means that the human pilot occupies the position of a supervisor who only has to introduce commands and then watch his aeroplane carry them out.

ALL-MANOEUVRE FLIGHT CONTROL SYSTEMS

Automatic pilots of the present day have adequate performance for navigational requirements when the primary objective is to land successfully at the intended destination. New performance requirements will lead to the development of flight-control equipment with radically new features. For instance, where two aircraft are engaged in air-to-air-fighting, the primary requirement for flight-control performance is success in combat, not a successful landing at a selected destination. This means that manoeuvres of all kinds must be realised to the ultimate performance limits of fantastically fast and powerful aircraft. To meet this specification, it is probable that the distinction between control co-ordinating systems and auto-pilots will disappear, so that an integrated flight-control system will actually become an essential part of a flight system that includes the airframe and its propulsion system.

PERSONAL

SIR WINSTON S. CHURCHILL, K.G., O.M., C.H., has accepted honorary membership of the Institution of Mining and Metallurgy, Salisbury House, Finsbury-circus, London, E.C.2.

SIR JOHN COCKCROFT, K.C.B., C.B.E., F.R.S., has been re-elected President of the Institute of Physics, 47 Belgrave-square, London, S.W.1.

MR. E. BRUCE BALL, C.B.E., has relinquished his appointments of managing director of Glenfield and Kennedy Ltd., and on the boards of Glenfield and Kennedy Holdings Ltd., Kilmarnock, and associated and subsidiary companies.

SIR PATRICK HAMILTON, Bt., has been appointed vice-chairman of the Expanded Metal Co. Ltd., Burwood House, Caxton-street, London, S.W.1.

MR. N. R. CRUMP, newly-elected President of the Canadian Pacific Railway Co., has announced the appointment of MR. D. S. THOMSON, of Montreal, as vice-president with jurisdiction over all the lines of the company.

MR. P. H. W. WOLFF has been appointed chief engineer of the newly-established atomic power-station development department of the English Electric Co. Ltd., at Whetstone, near Leicester. For the new development, the firm will work in conjunction with Babcock & Wilcox Ltd. DR. H. S. ARMS, M.A., M.I.Mech.E., F.Inst.P., now the chief engineer, English Electric Co., Rugby, will be responsible for the overall technical policies to be followed by all departments at Rugby and Whetstone.

MR. J. G. HOLMES, B.Sc., A.R.C.S., F.I.E.S., chief technical officer Holophane Ltd., has been elected honorary secretary to the Illuminating Engineering Society for the 1955-56 session. He was President of the Society in 1951-52.

MR. HARRY JEFFORD, has been elected chairman of the Institute of Packaging, in succession to MR. A. F. COWAN. MR. JAMES MORRIS has been elected vice-chairman.

CAPTAIN O. P. JONES, C.V.O., O.B.E., F.R.G.S., A.F.R.Ae.S., the most senior pilot of the British Overseas Airways Corporation, has retired on the conclusion of 33 years of flying with the Corporation and its predecessors.

MR. W. T. TOWLER, J.P., of Towler and Son, Ltd., and MR. G. S. WOOD, of Thos. W. Ward Ltd., have been elected to the Governing Council of the British Engineers' Association, 32 Victoria-street, London, S.W.1.

MR. D. N. RELF, M.B.E., A.M.I.E.E., has been appointed assistant manager, switchgear contracts, the British Thomson-Houston Co. Ltd., Rugby.

A new electronics department formed at Metropolitan-Vickers Electrical Co. Ltd., Trafford Park, Manchester, 17, now incorporates the former radio department, part of the marine and special contracts department, and the service electronics section of the industrial electronic control engineering department. The following have been appointed officers of the new electronics department. MR. E. T. W. BARNES, formerly superintendent, radio department, to be superintendent; MR. D. E. THORNHILL, B.Sc.Tech., to be assistant superintendent; DR. L. W. BROWN, formerly chief engineer radio department, to be chief engineer; MR. T. R. GOODE, formerly assistant chief engineer, radio department, to be assistant chief engineer; MR. J. L. RUSSELL, A.M.I.E.E., to be assistant chief engineer (special applications); MR. L. H. J. PHILLIPS, formerly sales manager, radio department, to be sales manager; and MR. J. NICHOLSON, formerly assistant manager, marine and special contracts department, to be assistant sales manager. MR. G. W. G. CANTER, formerly manager, marine and special contracts department, has been appointed manager, special contracts, and will be stationed in London.

MR. J. O. KNOWLES, chairman and joint managing director, Brookhirst Switchgear Ltd., and MR. J. T. RYMER, managing director, Sentinel (Shrewsbury) Ltd., have been elected to the board of Metal Industries Ltd., Universal House, 60 Buckingham Palace-road, London, S.W.1. The appointment to the board of SIR CHARLES WESTLAKE, at present chairman, Uganda Electricity Board, is also announced. MR. R. W. MCCRONE has retired from the board of Metal Industries Ltd. after 33 years as managing director and latterly as chairman, and MR. J. S. HUTCHISON has been appointed to succeed him as chairman. MR. J. T. RYMER has also succeeded MR. MCCRONE as chairman of Sentinel (Shrewsbury) Ltd., and he will hold the dual appointment of chairman and managing director.

MR. S. L. FINCH has been appointed joint managing director, together with MR. A. H. CATTON and MR. D. E. CATTON, of Catton & Co. Ltd., Yorkshire Steel Foundry, 29 Chadwick-street, Black Bull-street, Leeds, 10. MR. A. H. CATTON remains the chairman.

Following upon the resignation of MR. J. R. FERGUSON from Cooke and Ferguson Ltd., associate company of Crompton Parkinson Ltd., MR. A. F. KISTNER has been appointed general manager of the Cooke and Ferguson switchgear works, Manchester.

MR. HANS BRONNIMAN has been appointed works manager of Lake & Elliot Ltd.

MR. H. THOMSON has been appointed manager of the Glasgow branch of British Insulated Callender's Cables Ltd.

MR. THOMAS KAMESTER has retired after 29 years of service as an engineer in the southern industrial division of the Vacuum Oil Co. Ltd., at Bristol.

CAPTAIN K. ST. B. COLLINS, O.B.E., D.S.C., R.N., has been appointed hydrographer to the Navy, in succession to Vice-Admiral Sir Archibald Day, K.B.E., C.B., D.S.O., as from June 13.

MR. N. TANNER has been appointed to the vacancy on the board of Hathernware Ltd., Hathern, near Loughborough, Leicestershire, created by the retirement of MR. C. E. TAYLOR.

MR. V. LEHEL, A.M.I.Mech.E., M.I.Loco.E., has been appointed chief engineer of Alfred Wiseman & Co. Ltd., Carlisle House, 8 Southampton-row, London, W.C.1.

MAJOR H. M. BURTON has been appointed liaison officer, for the Middle East, of the Federation of British Industries, 21 Tothill-street, London, S.W.1.

MR. F. ANDERSON, A.M.I.C.E., who has been in charge of the Scottish office of the Cement and Concrete Association, at 2 Rutland-square, Edinburgh, since 1935, is to retire on June 1 after 28 years of service. His successor is MR. PETER RUSSELL, B.Sc., A.M.I.C.E.

MR. R. B. WHALLEY, A.M.Inst.W., has joined the staff of Metal and Pipeline Endurance Ltd., as chief welding engineer.

MR. E. L. TRIFFITT, A.M.I.C.E., has been appointed assistant civil engineer, North Eastern Region, British Railways.

CAPTAIN R. E. COWELL, R.D., A.D.C., R.N.R., has been appointed marine superintendent, Peninsular and Oriental Steam Navigation Co., in succession to the late CAPTAIN A. RODGER.

MR. G. W. WRIGHT, M.I.Prod.E., A.R.Ae.S., is being released from his appointment as general manager, engine division, Bristol Aeroplane Co. Ltd., Bristol, on August 31, to take up the position of executive director of the Asquith Machine Tool Corporation Ltd., and certain of its subsidiary companies. MR. G. L. HACK, M.I.Mech.E., is to succeed Mr. Wright as general manager, engine division, Bristol.

MR. R. F. HANKS, vice-chairman, Nuffield Organisation, has been appointed an additional member of the Western Area Board of the British Transport Commission, of which Board he will assume the chairmanship on July 1, in succession to MR. JOHN RYAN, member of the Commission, who agreed to act as chairman temporarily. Mr. Ryan will continue as the Commission's member on the Western Area Board after the chairmanship has passed to Mr. Hanks.

MR. E. R. WILLIAMS, managing director of Capamianto S.p.A., Turin, the Italian subsidiary company of the Cape Asbestos Co. Ltd., London and South Africa, has retired after 35 years of service. Mr. Williams is succeeded at Turin by MR. JOHN HILL.

MR. TIMOTHY ROOTES has been appointed executive assistant to the managing director, MR. G. COZENS, of Commer Cars Ltd., Luton. MR. DONALD BURGESS, formerly Rootes Group planning officer, has been appointed to the boards of Commer Cars Ltd., and Karrier Motors Ltd., and will assume the responsibility of works manager.

MR. D. N. MANTON has joined A.P.V.-Paramount Ltd., Crawley, Sussex, as Midland-area representative. MR. E. L. ILLSLY is now representing the company in the North of England.

MR. W. S. PENN, B.Sc., has joined Johnson & Phillips Ltd., Charlton, London, S.E.7, as chief rubber-cable technologist. He will be assisted by MR. V. RODMAN, A.I.R.I., as rubber-cable chemist. MR. H. J. WIGNER, A.M.I.E.E., has been appointed senior sales engineer.

MR. J. M. WHITE, lately chief sales engineer, George Kent Ltd., Luton, Bedfordshire, has been appointed to the London office on return from his present visit to Canada. MR. J. THAM has been appointed chief sales engineer, in succession to Mr. White.

MR. M. H. A. BARRY, A.M.I.Struct.E., is now in charge of the structural department of Steel Supply Co. (Eastern) Ltd., Bedford.

A. A. Jones and Shipman Ltd., Narborough-road South, Leicester, announce that MR. J. A. SPOKES, their Yorkshire representative, has now relinquished this appointment. This area, in future, will be covered by MR. T. MARSHALL, who has been with the company for over 25 years.

MR. LEONARD COLKETT has been appointed secretary to C. C. Wakefield & Co., Ltd., 46 Grosvenor-street, London, W.1, in succession to the late MR. S. G. JARVIS.

MR. L. K. BRINDLEY, M.B.E., has been elected deputy chairman of the Mond Nickel Co. Ltd. and Henry Wiggin & Co. MR. G. ARCHER, C.M.G., has been elected managing director of the Mond Nickel Co. MR. I. A. BAILEY is moving his headquarters from Birmingham to London, where he will continue as a director of the Mond Nickel Co. and as managing director of Henry Wiggin & Co. DR. L. B. PFEIL, O.B.E., F.R.S., has relinquished the managership of the development and research department in order to devote himself more fully to directorship responsibilities. MR. R. A. R. HILL has been elected a director of the Mond Nickel Co. and to the offices of comptroller of the Mond Nickel Co. and of Henry Wiggin & Co. MR. F. B. HOWARD-WHITE has been elected a director of Henry Wiggin & Co. and secretary of the Mond Nickel Co. and of Henry Wiggin & Co. MR. J. O. HITCHCOCK has been elected a director of the Mond Nickel Co., and appointed sales director. MR. F. DICKINSON has been appointed manager of the development and research department. MR. A. P. HAGUE continues as a director of the Mond Nickel Co. and Henry Wiggin & Co., and DR. A. G. RAMSAY as a director of the Mond Nickel Co. resident in South Wales.

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COMMERCIAL

THE ENGLISH STEEL CORPORATION LTD., River Don Works, Sheffield, 9, have formed a new wholly-owned subsidiary company, entitled DAVIS & LLOYD (1955), LTD., which has taken over the interests of Davis & Lloyd Ltd., of 26, Victoria-street, London, S.W.1, in the design and production of cast-steel side frames, bolsters, unit brake beams and other parts and appliances for railway rolling stock. MR. ERNEST LLOYD, who has retired from the company, will continue to be available in a consultative capacity and MR. F. MASON, a director of the old company, becomes a director of the new company. MR. F. PICKWORTH and DR. C. J. DADSWELL become chairman and managing director, respectively, and MR. F. S. BEALE becomes a director of the new company.

NAGARD LTD., 18, Avenue-road, Belmont, Surrey, announce that their telephone number has been changed to VIGilant 9161–2).

THE A.P.V. CO. LTD., Wandsworth-Park, London, S.W.18, have formed a new Canadian company, A.P.V. (CANADA) EQUIPMENT LTD., to take over WALKER-WALLACE LTD., Toronto, which firm have been their Canadian agents since 1929. MR. K. L. WALLACE will continue as President of the new company with MR. H. J. A. PAINTER, the present vice-president.

JOHNSON & PHILLIPS LTD., Charlton, London, S.E.7, have opened a new depot at Spital House, Spital Hill, Sheffield, 4. (Telephone: Sheffield 22893). The depot will be in the charge of MR. P. C. DOUGHERTY who was previously at the firm's Ipswich branch.

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ELECTRICITY SUPPLY IN APRIL

Changes Due to Re-organisation

The schedules showing the electricity sold by the Central Electricity Authority and sent out by the Area Boards to their consumers during April, 1955, are the first to apply to England and Wales alone, figures for Scotland being omitted owing to the recent re-organisation. Some falling off in the gross figures is therefore noticeable.

During April, 1955, 5,121 million kWh were sold by the Central Authority to the Area Boards. This was an increase of 8·4 per cent. over the figure for April, 1954, for the same area. When corrected for weather conditions and working days the increase was, however, 11·8 per cent.

The amount of electricity sent out by the English and Welsh Area Boards during the same month was also 5,121 million kWh, of which 135 million kWh were supplied direct by the Central Authority. The increases in the amounts sent out, compared with the corresponding figures in April, 1954, were 8·6 per cent. in the "mainly industrial" and 6·2 per cent. in the "mainly non-industrial" areas.

Letters to the Editor

FUNDAMENTAL CONCLUSIONS FROM SUPERFICIAL DATA

An Ideal in Education

SIR, Mr. A. Prince (his letter in your issue of May 13) would not have been "surprised" at my use of the word "superficial" if he had referred to the Concise Oxford Dictionary. To suggest that what lies "on the surface" is "of insignificant import," in this context, is to challenge the whole basis of natural philosophy. As Mr. Prince has so completely missed the point of my brief letter I offer a word of elucidation.

Einstein was outstanding not for what he knew at the age of 26, but by reason of the far-reaching conclusions which he deduced by logic and analysis from the relatively simple observation that the measured speed of light is unchanged by the motion of the observer. In this he exhibited qualities which educational institutions should foster, in the time that can be spared from the retailing of straight knowledge, even though the student's ability to derive pertinent conclusions from superficial data may never approach that of an Einstein, a Newton, or a Rutherford.

Yours faithfully,

E. H. BATEMAN.

Highlands,
St. James-road,
Sevenoaks, Kent.
May 17, 1955.

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THICK-WALLED CYLINDERS UNDER INTERNAL PRESSURE

SIR, Allow me to reply to Dr. Crossland's and Mr. Bones's remarks in your issue of May 6, page 553. I do not deny that at bursting pressure the formula $P = R \log_e K$ may no longer be applied. This formula is only theoretically exact when the deformation may be neglected, or so long as K remains constant.

I recommend this and the other formula for thick-walled cylinders, prescribed by the German D.I.N.2413. Please address your remarks to the writers of this German standard.

Yours faithfully,

F. VAN ITERSON.

May 11, 1955.

SIR, In Professor van Iterson's letter of May 11 he agrees effectively that his equation is not applicable to a thick-walled cylinder made from a ductile material, as the K of such a cylinder would decrease significantly before the ultimate pressure was reached. He says that the equation $P = R \log_e K$ is only theoretically correct when the deformation can be neglected, but we cannot agree that it is even applicable to this case unless the material does not strain harden, that is, the engineer's ultimate stress and the plastic yield stress are equal. We think that Professor van Iterson would agree that this is hardly a practical case.

We would again emphasise that our work demonstrates beyond doubt the validity of the theory put forward in a most practical form by Mr. W. R. D. Manning.

Yours faithfully,

B. CROSSLAND,
J. A. BONES.

Bristol.
May 16, 1955.

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TECHNICAL STAFF FOR BRITISH RAILWAYS

Attracting Men from Other Industries

SIR, It is good to hear that someone whose word should carry weight has been given specific responsibility for the recruitment of technical staff. Mr. Quartermaine has a hard road before him. His is the responsibilitity for stemming, and reversing, the flow of technical staff that has drained from the railways for perhaps 40 years or more.

Your correspondents (May 6 and May 20), have put the case for increasing the salaries of technical staff. This is certainly a matter for Mr. Quartermaine to study if non-railwaymen are to be attracted to the service. But surely an even more important problem one much more difficult to solve, is that of creating conditions which will induce such men to remain with the railways? As the railways have been starved of the best men for many years, it follows that many of the more senior posts must have been filled by the not-so-good. If this is so—and no one who has had more than superficial contact with the railways could deny it—it will often be difficult to place new entrants where they will not get frustrated and then leave the service before promotion comes to them.

One solution to this impasse would be to create new groups alongside the old, taking staff both from other parts of the railways and from outside; to form, for example, a lightweight train design section by appointing as section leader a man with experience of aircraft or road vehicles and drawing his staff partly from railway drawing and design offices and partly from other industries. Of course, only a limited number of projects can be tackled in this way, but such groups would not only bring with them a flood of new ideas but would also create openings in the railways for the more senior men who, because of their lack of railway experience, could not immediately take senior posts in other branches of the railway.

No organisation can, in the long run, be better than its staff. Let us hope that we will soon be able to attract (and keep) our fair share of the best brains—even at the expense of atomic energy or electronic computors!

Yours faithfully,

D. L. TURNER.

37 Albert-road,
Ashford, Kent.
May 19, 1955.

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CONVERSION OF INCH AND METRIC DRAWINGS

Real Need for Precision

SIR, I have noted with interest Mr. Conway's rather sweeping comments, in his letter in your issue of May 13, on the suggested procedure for the conversion of inch and metric limits given in my recent article. I was glad to read that he agrees that in cases where it is necessary to have strict dimensional interchangeability of parts made respectively to inch and to metric drawings then a high precision of conversion is required. As stated in my article, it is for precisely these cases that the procedure was formulated although the procedure lends itself to all cases of conversion. Mr. Conway's main criticism is that the number of cases where this strict dimensional interchangeability is required is very small, and therefore a conversion procedure utilising a high precision of conversion is unjustified. I think that Mr. Conway underestimates the importance of this aspect of the conversion problem, and I believe the following information will show this.

The scheme outlined in my article was initially prepared for the British Standards Institution Electronic Tubes and Valves Committee, which is responsible for the preparation of Standards for valve bases and holders. In these Standards the inch and metric dimensions of the pins, holes and other features of the valve bases and holders are given side by side. Up to the present time this Committee has been using a procedure for conversion based on a relatively coarse precision of conversion. This Committee has recognised that this procedure is not completely satisfactory as it has resulted in loss of tolerance to manufacturers working to the converted limits and has also introduced troubles in inspection.

As Mr. Conway is now aware, difficulties encountered in the small-tool trade in this country have arisen as a result of appreciable differences between metric dimensions and their inch equivalents. In supplying certain types of small tools for export abroad it has been necessary in a number of cases to revert to the original metric dimensions and reconvert to a high precision.

As regards weapon production, to which Mr. Conway made reference, the universal interchangeability of parts made in Great Britain and abroad is now in many cases a necessity. The conversion of limits from one set of units to another, using a low precision of conversion, would lead to difficulties in the assembly of mating parts of weapons made respectively in this country and on the Continent.

No doubt, other cases could be quoted in which a high precision of conversion is necessary to maintain universal interchangeability of parts made here and abroad, rather than what may be termed "local interchangeability" within this country alone.

Turning now to Mr. Conway's criticism of rounding to the nearest "half tenth" in cases where small tolerances are involved, I would make the following remarks. The example quoted by him has a tolerance of 0·0012 in. and with the proposed scheme the inch limits are 0·98425/0·98545 in. Inspection of work produced in large quantities and having tolerances of 0·0012 in. would normally be expected to be carried out by "Go" and "Not Go" gauges, and the drawing limits are used only to define the gauges. According to B.S.969:1953, for a work tolerance of 0·0012 in. the recommended tolerances for plain plug and ring gauges are 0·0001 in. It is, in my opinion, a matter of little concern to the gauge maker whether he has to make a gauge to say limits 0·98425/0·98435 in. as would be the case with my proposals, or to limits 0·9843/0·9844 in. as Mr. Conway suggests. In both cases a gauge tolerance of 0·0001 in. is employed.

The object in publishing the recommended procedure was to provide some guidance to manufacturers who are faced with similar problems to the above. At the present time there is, to the best of my knowledge, no alternative scheme available for the use of industry.

Yours faithfully,

L. W. NICKOLS.

Metrology Division,
National Physical Laboratory,
Teddington,
Middlesex.
May 17, 1955.

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ROYAL AERONAUTICAL SOCIETY AWARDS

The following awards have been made by the Royal Aeronautical Society and were presented by the President, Mr. N. E. Rowe, before the 43rd Wilbur Wright Memorial Lecture on Thursday, May 19: the Society's Gold Medal to Lord Hives for work on the propulsion of aircraft; the Society's Silver Medal (two awards) to Dr. R. A. Frazer for work on aerodynamics over many years and to Dr. A. A. Griffith for research on aircraft engine design; the Society's Bronze Medal to Professor M. J. Lighthill for contributions to aeronautical knowledge; the Wakefield Gold Medal to Mr. J. Taylor for the design and development of the counting accelerometer; the British Gold Medal to Mr. G. H. Dowty for the design and development of aircraft accessory systems; the British Silver Medal to Dr. S. G. Hooker for the design and development of aero engines; the George Taylor of Australia Gold Medal to Mr. R. C. Morgan for his paper on "Practical Experience of Airline Engineering"; and the Simms Gold Medal to Dr. D. Williams for his paper on "Recent Developments in the Structural Approach to Aeroelastic Problems."

ANNUAL GENERAL MEETING OF INSTITUTION OF NAVAL ARCHITECTS

The proceedings on the third and final day of the 1955 Spring Meeting of the Institution of Naval Architects, April 6, began with the annual general meeting of the Institution, at which the chair was taken by the President, Viscount Runciman of Doxford, O.B.E., A.F.C., D.C.L.

The annual report of the Council was presented in summary by the secretary, Captain (S) A. D. Duckworth, R.N. (ret.) and, on the motion of the President, was adopted without discussion. An account of the technical session that followed the annual general meeting is given on page 659 of this issue.

ANNUAL REPORT

The annual report again shows an increase in the membership of the Institution, which, at December 31, 1954, stood at a total of 3,728. It is noted that, while the numbers of Members and of Associate Members both increased—the latter by 4 per cent.—there were small reductions in the numbers of Associates and of Students. The report reflected modern economic changes in stating that, to make available scholarships of higher value, the Council had decided to combine the existing Elgar, Martell and Institution scholarships to produce one of the value of £275 per annum, to be known as "The I.N.A.-Elgar-Martell Scholarship," to be first awarded in 1955. At the 1954 Autumn Meeting, in Torquay, a bronze plaque was unveiled by the President on the site of William Froude's original experiment tank at Chelston Cross; and, on behalf of the Institution, the Council have also presented a tablet in memory of Froude, to be erected in the main entrance to the Town Hall, Torquay. As announced at the inauguration of the Weir Lecture Hall, the Institution has received a Grant of Arms from the College of Arms, the necessary expenses of which are being borne by John Brown and Company (Clydebank), Limited. In preparation for the Institution's centenary in 1960, the Council have asked Mr. K. C. Barnaby, O.B.E., B.Sc.—whose grandfather, Sir Nathaniel Barnaby (1829-1915), was one of the 18 founder members—to compile a history of the Institution's activities between 1860 and 1960. The summary of the considerable amount of research work in which the Institution is interested, which formed part of the report, mentions, *inter alia*, that, in consultation with Vickers-Armstrongs Limited, Weybridge, a radio control mechanism has been developed at the National Physical Laboratory to enable a twin-screw model to be manoeuvred in the experiment tank, in place of the present method of using a swinging arm on the tank carriage to support electric cables, connected to the model.

Following the adoption of the annual report, the annual accounts and balance sheet were presented by the Hon. Treasurer, Instructor Rear-Admiral Sir Arthur E. Hall, K.B.E, and were also adopted without discussion.

ELECTION OF COUNCIL AND OFFICERS

The ballot for vacancies on the Council resulted in the election, as Vice-Presidents, of Mr. R. B. Shepheard, C.B.E., B.Sc., Professor E. V. Telfer, D.Sc., Ph.D., and Mr. James Turnbull, O.B.E.; as Members of Council, of Mr. A. Aikman, O.B.E., Dr. J. F. Allan, Mr. J. H. B. Chapman, Mr. J. Ramsay Gebbie, C.B.E., B.Sc., Mr. I. E. King, C.B.E., Mr. W. H. McLay, Mr. Allan J. Marr, B.Sc., Mr. J. M. Murray, M.B.E., B.Sc., Mr. H. S. Pengelly, Mr. J. S. Redshaw, O.B.E., and Sir William Wallace, C.B.E.; and, as Associate Members of Council, of Sir Lawrence Edwards, O.B.E., D.L., J.P., Professor Sir Thomas H. Havelock, M.A., D.Sc., F.R.S., and Mr. Gilbert Innes. Instructor Rear-Admiral Sir Arthur E. Hall was re-elected as Honorary Treasurer.

The President reported that Mr. E. L. Champness, M.B.E., M.Sc., and Sir Charles S. Lillicrap, K.C.B., M.B.E., D.Sc., had been elected as Honorary Vice-Presidents of the Institution in recognition of their long and valuable services. He then presented to Dr. G. Hughes the Gold Medal of the Institution, awarded to him for his paper on "Friction and Form Resistance in Turbulent Flow, and a Proposed Formulation for Use in Model and Ship Correlation"; and announced the award of an Institution Premium to Lieut.-Commander J. N. Bathurst, O.B.E., D.S.C., R.N., for his paper on "Underwater Television." Other awards, announced in the annual report, were as follows: the Duke of Northumberland Prize, to Mr. Raymond Adams, of Aberdeen; a prize of instruments and books, through the City and Guilds of London Institute, to Mr. T. S. Ferguson; a Watts Prize, of £25, to Mr. T. L. Mackie, M.B.E., for a paper on "Shipborne Pests and a new Insecticidal Treatment"; and a Samuel Baxter Prize of £50 to Mr. J. W. Thurston for work in connection with the Tonnage Measurement Laws Committee and the Merchant Shipping Act, 1954.

The President then delivered his address, as follows:

PRESIDENTIAL ADDRESS

Lord Runciman said: "This past year has been, like so many other years, one in which nothing particularly spectacular has happened in naval architecture, but wherein there has been considerable progress in a good many directions. Moreover, it has been a year in which the outlook for shipbuilding has appeared rather more hopeful towards the end than, perhaps, it did at the beginning; in the state of the order books for merchant ships and in the amount of naval construction, both completed and on hand, the year was no worse, and perhaps a little better, than the one that went before.

"The Royal Navy has completed, over the past twelve months, three aircraft carriers, three small submarines, 32 coastal minesweepers, 35 inshore minesweepers, five fast patrol boats, 12 seaward patrol craft and a fleet oil tanker. Meanwhile, a considerable amount of work has been done, and progress can be recorded, on improving living conditions for those who have to serve in large numbers and rather small spaces in Her Majesty's ships. We know that, in the Merchant Navy, accommodation is always something of a problem; what it must be like to cram inside a fighting machine of the concentration and complexity of modern naval craft a very much larger complement and more equipment which will be required should the need arise, and to provide for the longer periods of peace, is something which will have to engage the attention not only of the Royal Corps of Naval Constructors, but of naval architects generally, for some time to come. There has been considerable progress, too, in trying to reduce the cost of maintenance in the Navy. Experiments are going on in connection with the cathodic protection of ships in the Reserve Fleet, which, I understand, should and we hope will effect considerable economies over a period. The Navy is experimenting also on the use of plastics for small craft; but I think you will agree that it will be quite a long time before we are likely to have a plastic aircraft carrier.

"On the merchant shipbuilding side, the order books are more full than, perhaps, the shipowners would care to see, but not so full as the shipbuilders would wish to see them. There is a higher proportion of dry-cargo tonnage on the order books, which seemed at one time to be filled very largely with orders for tankers. Whether that means that the number of tankers in the world is getting somewhere near what it ought to be, that the leeway has been made up in tanker construction, I do not know, but it looks rather like it. Even so, over a period that is probably a healthy sign.

"On cargo ships I speak feelingly when I say that one still notices with sadness the relative decline in tramp tonnage flying the flag of this country; and, indeed, with some slight apprehension in observing the flags of countries we do not normally associate with the operation of a large mercantile marine. I do not propose to weary you with a disquisition on either of the two topics which agitate the minds of shipowners particularly at the present time, namely, discrimination against the free use by shippers of tonnage under any flag which they think suits them at any time, in order that certain countries not naturally very well qualified to own or run ships may increase their mercantile marines; and the increasing use of what have come to be known as "flags of convenience." These are both matters which directly affect shipowners and indirectly, I think, may affect shipbuilders to some extent as time goes on.

"What will certainly affect British shipbuilders, and has already begun to do so, is direct foreign competition in shipbuilding. It is extremely easy for the shipowner to say that all you have to do is to get your costs down. Obviously, the British shipowner will place his orders in British yards if he can possibly do so. It is important that the temptation to him, whether on price or delivery, to place his orders abroad does not become overwhelming. How those costs are to be brought down it is not for me to say, except perhaps to remark that, so far as the outside observer can distinguish between the more expensive and the less expensive yard, at home or abroad, a good deal of the difference seems to lie in the facility with which the steel and the prefabricated work is brought alongside the berth and set up for inclusion in the vessel. That raises numerous difficult and complicated problems—problems of site, of layout, of turning a whole yard upside down in the hope that it may be better afterwards. I have no doubt that the costs of labour and steel are likely to remain at least as high as they are to-day and may possibly become higher. A real economy is to make sure that the labour and material are brought together and made into a ship with the smoothest possible flow and the least possible interruption and delay.

"There are continuing and not uninteresting developments in propulsion, and the two most in the public mind are the use of the gas turbine and, behind it, the use of atomic energy. It is fairly clear that any great development in either may well bring in its train developments in the design of the ships which are to contain such machinery. There are two points, one in connection with each of these forms of propulsion, which are becoming rather surprisingly of immediate interest; those are the effects upon the health of those who will be associated with them of power plants of this character, and their fuels. We know very well what things have to be guarded against in the use of atomic power and radiation. What is not, I think, so generally known, but is beginning to be rather unpleasantly discovered, is the effect upon health of the vanadium components which are now coming into fuels, particularly for gas turbines; that may well become a serious problem if it is not carefully watched. It seems to me that it must, in turn, lead to some matters for consideration from the purely naval architectural point of view in the design of the ships, to assist in any methods which may be adopted to keep that sort of thing under control.

"Finally, one is glad to see the usual crop of researches of every kind going on. I do not propose to refer specifically to any of them, nor indeed to repeat what has been said so frequently, how necessary research is, and how much very worth while. So I say again that this past year has been one of steady but not spectacular progress. Naval architecture, after all, is like that; it is extremely improbable that we shall find in that art or science any really revolutionary change such as will put every existing ship out of date in a fortnight. We are more likely to pursue as steadily as we can our search, not for the perfect ship—I do not think that is possible—but for the best compromise in trying to find it."

Obituary

MR. A. T. BEST

Extensions to Docks and Harbours

It was with regret that we learnt of the death, on Monday, May 16, of Mr. A. T. Best, M.I.C.E., who was, until his recent retirement on account of ill-health, consultant to Rendel, Palmer and Tritton, of Victoria-street, Westminster, since April, 1946.

Alfred Thomas Best was born on October 27, 1877, and obtained his general education at Fulham Grammar School, which he attended between 1885 and 1891. Then only 14 years old, he went into the office of his brothers, Mr. Charles W. Best and Mr. H. Robertson Best, MM.I.C.E., where he received his practical training until 1898 when he was 21. In the following six years he was employed as an assistant to his brothers, who were then practising as Best and Sons, consulting engineers. During this period he was engaged in the design and supervision of numerous works for drainage and water supply, being stationed successively in London, Oxford, Brecon and Cannes (France), and he remained in France for a further period of two years. In 1907 he joined the staff of the Breconshire County Council where he became deputy county surveyor, assisting his brother Charles, who by then was the county surveyor.

In 1911 Mr. Best began his connection with dock and harbour work which was to be his principal occupation for the remainder of his professional career. As an assistant with the Port of London Authority he served under Sir Charles R. S. Kirkpatrick, the then chief engineer of the Authority, and Mr. Asa Binns, who was then engaged as resident engineer on the construction of the King George V Dock and of the cold stores at the Albert Dock. From 1920 until 1925 he was with the British Petroleum Company, Limited, as chief assistant engineer under the late Mr. F. J. Rigg, M.I.C.E., directing the construction of oil installations.

It was in 1925 that Mr. Best joined Rendel, Palmer and Tritton, and from that date he was responsible as chief assistant in the Dock Department for harbour extensions at Takoradi on the Gold Coast (where, incidentally, the firm have recently undertaken further extensions) and at the West India and Tilbury Docks for the Port of London Authority. Between 1929 and the outbreak of the war he was engaged on the design and administration of a number of important projects which included, among others: improvements to the Royal Dock approaches, London; Haifa Harbour; the survey of the Haifa-Baghdad Railway; Chelsea Bridge; and, finally, Waterloo Bridge.

From 1939 he was engaged on war work, particularly in connection with the erection of Royal Ordnance factories and of air-raid shelters in the Westminster area. In the post-war period he was mainly concerned with road-development work for the Ministry of Transport; these works included the Neath By-pass and other roads in South Wales as well as the elimination of level crossings on the North Eastern Region, British Railways. In 1946, as already noted, he was appointed a consultant to his firm, the position he retained until his retirement.

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TURBINE GENIUS

Film on C. A. Parsons: the Man and the Company

Giotto to prove his identity is reputed to have drawn freehand a perfect circle; Charles Algernon Parsons gave similar evidence of genius by sketching on the back of an envelope the ideal aerofoil profile for a turbine blade, No experimental data were then available, and this section, with only minor modifications, remained standard for nearly 40 years and differed little from present blade forms based on systematic study. Parsons' remarkable intuitive faculty and his great inventive and engineering talent are well portrayed in a film entitled " Parsons—The Genius of Power " produced as part of the proceedings to commemorate the centenary of his birth. The film provides a brief history of his life and work, together with a description of the company he founded and its activities today.

The Hon. Sir Charles A. Parsons, O.M., K.C.B., F.R.S., was responsible not only for the development of the steam turbine but also for its application to electric-power generation and marine propulsion; in addition he made important contributions in the field of optics—his father was an eminent astronomer—and in 1889 he established the firm of C. A. Parsons and Company, Limited, Heaton Works, Newcastle-upon-Tyne, 6. All these aspects of his work are covered in the film, which illustrates too the products of the modern organisation from searchlight reflectors and generating plant to well-trained engineers. The film, which is in 35 mm. and 16 mm. gauges and runs for 35 minutes, was made by the Pathe Documentary Unit.

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BOOK REVIEWS

Oxford Junior Encyclopaedia. Vol. VIII: Engineering. *Oxford University Press (Geoffrey Cumberlege), Amen House, Warwick-square, London, E.C.4.* (30s.)

The Oxford Junior Encyclopaedia consists of twelve volumes, and has been designed principally as a reference work for school libraries. Part of the aim of the encyclopaedia is to encourage the habit of reading; every article has been written to stimulate interest so that the child, having used the encyclopaedia once, wants to read more. At the same time it is intended as a work of reference for older students and adults, occupying a position mid-way between the large standard encyclopaedias and the popular alternatives. The work as a whole claims to be reasonably comprehensive, although limits have been imposed by the immense field covered; chief among these limits is that matter already easily available in school text-books is included only if it is necessary for a proper understanding of the subject under discussion.

The eighth volume, Engineering, describes how man uses nature's resources by forging tools, constructing machinery, harnessing power, and erecting great engineering works. There are articles describing the basic properties of engineering materials, such as expansion and contraction, stress and strain, and friction, and the principal branches of engineering, such as mechanical, electrical, chemical and civil engineering. Some mention is also made of those branches of science and mathematics which have particular bearing on engineering. Sources of power and various types of machine tool are discussed, and there are articles on certain outstanding engineering feats, such as the Kitimat hydro-electric scheme and the reclamation of the Zuider Zee.

This volume is linked with the other eleven volumes by comprehensive cross-references, but each article is complete in itself. The cross-references serve to give additional information either on particular points or people, or on general principles. The plan of all volumes has allowed for a large proportion of illustrations to text (between one-quarter and one-third of the total space), and the illustrations, some of them photographs and some of them line drawings, save paragraphs of explanation and in many cases make understanding of the articles much more rapid.

The only criticism of this volume, however, lies in the illustrations. Although most of them are of great help in using the encyclopaedia, some are not very clear or do not emphasise points brought out in the text. Another fault is that the captions are in most cases too short; advantage has not been taken of the opportunity to point out the salient features of the illustrations, or to relate the illustrations to the text. Conversely, the text does not always refer to the illustrations, and only occasionally does it refer to them in detail.

The faults in illustration detract but little from the value of the book as a whole. The text of the articles is almost invariably lucid and simple, and it will not be only schoolchildren who will benefit from this volume. Engineers will find practices and principles of other branches of engineering clearly explained, and for those who have superficial dealings with many branches of engineering it could be a most useful reference work. For the layman of any age the book is a mine of interesting and useful knowledge.

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CONTRACTS

Substation. The Central Electricity Authority have placed a contract valued at £364,000 for a 132-kV outdoor substation with the GENERAL ELECTRIC CO. LTD., Magnet House, Kingsway, London, W.C.2. The substation will form part of the new base-load generating station now under construction at Willington, near Derby, in the East Midlands Division. It will control 6 feeders linking Willington with Spondon, Allenton, Winster and Drakelow on the existing 132 kV grid system, and two feeders linking with the 275 kV supergrid.

Bridging. Callender-Hamilton bridging to the value of £118,000 has been ordered from the BRITISH INSULATED CALLENDER'S CONSTRUCTION CO., LTD., by the Government of New South Wales, for road reconstruction work in the areas recently devastated by floods. The bridges, which will have a total road width of 24 ft., will provide for two lanes of vehicles and will be able to carry heavy traffic. Some will have footways cantilevered outside the main girders. The protection of the steelwork will be by hot-dip galvanising. The bridges, which are urgently required, are to be fabricated and galvanised by PAINTER BROS. LTD., Hereford.

Telecommunications Equipment. The Companhia Telephonica Brasileira have placed contracts with STANDARD TELEPHONES AND CABLES LTD., Connaught House, Aldwych, London, W.C.2, through Standard Electrica S.A., Brazil, for a complete multi-channel coaxial-cable route and a super-high frequency radio network, also for multi-channel telephony, and similar to that installed by Standard Telephones and Cables, in 1952, for conveying television programmes between Manchester and Kirk o' Shotts in Scotland. The coaxial cable route represents the first link in the proposed Brazil network and has been installed between Rio de Janeiro and Petropolis, 65·5 km. north of the capital. The network of super high frequency radio links covers a distance of about 300 miles and will link Sao Paulo to Rio de Janeiro and also to Campinas.

Gear-Hobbing Machines. An order from an American company for two gear-hobbing machines valued at over 100,000 dols. has been received by DAVID BROWN MACHINE TOOLS LTD., Sherborne-street, Manchester. One is a large machine, weighing about 52 tons, capable of producing gears up to 138 in. in diameter of the exceptional accuracy normally associated with turbine gears for marine main-propulsion drives. The other machine is an M.T.60 gear hobber, which is a universal machine for cutting spur, helical, spiral and worm gears up to 60 in. in diameter. It weighs 12 tons.

Helicopters. An order for the supply of two S.55 helicopters and spares has been placed with WESTLAND AIRCRAFT LTD., Yeovil, Somerset-by Bahamas Helicopters Ltd., Nassau. The two aircraft will be equipped with seats for nine passengers and will be fitted with floats to enable them to land on the sea if need be. Delivery of the first machine is scheduled for June, and the second will be delivered during the following month.

Railway Electrical Substation and Track-section Cabin Equipment. The whole of the electrical substation and track-section equipment for the extensions of the Liverpool-street-Shenfield railway electrification to Chelmsford and Southend (Victoria) has been placed with the BRITISH THOMSON-HOUSTON CO., LTD., Rugby. The electrification extension covers a total route of 32 miles. Five 2,000-kw, 1,500-volt pumpless steel-tank rectifier equipments are to be supplied and will be installed in four substations situated at Hylands, Ramsden Bellhouse, Rayleigh and Prittlewell, the last-named being a two-unit substation near the Southend terminal. The four substations and four track-section cabins will be controlled from the existing supervisory control station at Chadwell Heath.

BOOKS RECEIVED

Some of the books noticed here are selected for extended review in later issues of ENGINEERING.

Studies on Bridge-Deck Systems: 1—Tests on a Model Jack-Arch Slab. By A. SHORT and R. I. LEWIS. National Building Studies Research Paper No. 21. Published for the Department of Scientific and Industrial Research by *H.M. Stationery Office, Kingsway, London, W.C.2.* (4*s.*)

The design of steel-concrete bridge-deck systems is at present based mainly on arbitrary assumptions, and experience has shown that the reserve of strength in such structures is much greater than that calculated. The present publication is concerned with the behaviour of jack-arch slabs. It outlines the theory of the jack-arch and describes tests carried out at the Building Research Station on a model jack-arch slab built in accordance with the design of a full-scale bridge selected as representative of its class. The model slab, which was supported on a span of 9 ft., was subjected to three groups of tests. It was first tested at working loads, then at working loads after systematic cracking of the concrete, both with and without tie-bars. Finally tests to failure were made, including tests on bending and punching strength. The publication describes the tests and test results in detail. From the test data it was possible to deduce the effective cross-section for the slab tested and a later report will give general guidance on the design of jack-arch bridges.

The Earnings of Industry. Published by Hollis and Carter, Limited, for *Aims of Industry, Limited,* 12 *Carteret-street, London, S.W.*1. (4*s.*)

This publication aims to show to the public the true relation between the profits earned by producers, and the wages, salaries and cost of materials. Most of the information is presented in tabular form and presents a sample breakdown of each £ of receipts in some of Britain's leading companies, showing the proportion taken by wages, and in many cases the additional benefits which supplement the agreed wages. Other subjects covered include taxation, strikes and organised labour, and a separate chapter is devoted to motor-car producing firms.

Water Engineer's Handbook, 1955. Compiled by the Staff of "Water and Water Engineering." 23rd edition. *The Colliery Guardian Company, Limited,* 30 *and* 31 *Furnival-street, Holborn, London, E.C.*4. (18*s.*)

This directory of water undertakings in the British Isles also includes sections on waterworks statistics; hardness of water as supplied to consumers in England and Wales; a list of water engineers, managers, consulting engineers, and their authorities; the Reservoirs Act, 1930; river boards in England and Wales, and in Scotland; Civil Defence (Water Supply) Regulations, 1949; government departments; institutions and associations; British Standards; and various technical data.

Fishing Boats of the World. Edited by JAN-OLOF TRAUNG. Published in co-operation with the Food and Agriculture Organization of the United Nations, by "*Fishing News,*" *Arthur J. Heighway Publications, Limited, Ludgate House,* 107 *Fleet-street, London, E.C.*4. (90*s.*)

This volume is a record of the papers and discusssions at the Fishing Boat Congress organised by the F.A.O. in the autumn of 1953. There were 70 contributors from many different countries, and their papers have been grouped into four main parts, boat types, naval architecture, engineering, and factory ships. There are 600 illustrations, 75 tables and a comprehensive index.

Work Study in Theory and Practice. A Summary of Eight Papers read at the British Productivity Council Work Study Conference, March, 1955. *British Productivity Council,* 21 *Tothill-street, London, S.W.*1. (9*d.*)

The eight papers summarised in this pamphlet are as follow: Work Study in the Factory; Work Study and the Trades Unions; The application of Work Study in the Printing Industry; The application of Work Study in the Furniture Industry; The Introduction of Work Study in the Smaller Firm; Human Problems in the Application of Work Study; The Application of Work Study to Batch Production and Clerical Operations; The Application of Work Study in a Hosiery Firm.

Ceylon. Overseas Economic Survey. By C. E. THOROGOOD. Published for the Board of Trade, Commercial Relations and Exports Department, by *H.M. Stationery Office, Kingsway, London, W.C.*2. (4*s.*)

Opportunities for United Kingdom exporters to take an increasing share in supplying Ceylon's needs of more imported manufactures and equipment for her secondary industries are outlined in this volume, the latest addition to the series of Overseas Economic Surveys. A statement by Sir John Kotelawala of his Government's policy for the attraction of foreign capital is quoted at length by the author, and rules defining the conditions that must be satisfied by individuals, partnerships and companies if they are to qualify for recognition as Ceylonese firms are reproduced. Various irrigation projects that invite the constructive attention of British industry are reviewed, and Ceylon's own resources, legislation, administration, communication, and communal and social problems are examined.

Equalizing Reservoir Dams and the Feeder Canal: Technical Record of Design and Construction. *United States Department of the Interior, Bureau of Reclamation, Denver, Colorado, U.S.A.* (No price given.)

This volume comprises a complete record, illustrated by drawings and photographs, of the design and construction of the dams for the equalising reservoirs and of the feeder canal associated with the Grand Coulee dam of the Columbia Basin project. The project is located in the centre of the State of Washington and is intended to effect the reclamation of over 1 million acres of semi-arid land. Note is made in the report of the choice of site, expedients used, quality and quantity of materials, labour employed and costs incurred, progress and causes of delay experienced during the period of construction.

La Mécanique au XVIIe Siècle. By RENÉ DUGAS. *Editions du Griffon, La Neuveville, Switzerland.* (48 Swiss francs.)

This book is a review of the development of the conceptions of natural science derived from experimentation, observation and deductions of varying and opposing schools of thought in different countries. The views of the leading philosophers are clearly stated and discussed. An English edition of the book is in preparation.

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TRADE PUBLICATIONS

Copies of any of the following trade publications are obtainable from the addresses given, though distribution is sometimes restricted.

Ground Silica and Foundry Bonding Material. COLIN STEWART LTD., Wharton Lodge Works, Winsford, Cheshire. Three leaflets, unillustrated, giving technical notes on (*a*) the uses and properties of ground silica; (*b*) the properties of Tripoli powders, fine-grained absorbent silica for polishing and buffing; (*c*) the development of Quest Standard Bentonite as a foundry bonding material with properties as good as those of Wyoming Bentonite.

Industrial Vacuum Cleaning. STURTEVANT ENGINEERING CO. LTD., Southern House, Cannon-street, London, E.C.4. Illustrated brochure giving particulars of their industrial vacuum cleaners and tools, portable flue-dust collecting plants, turbo-blowers and exhausters, mobile "central" cleaning installation, and some applications in industry.

Nickel and Nickel Alloys. HENRY WIGGIN & CO. LTD., Wiggin-street, Birmingham, 16. Nickel and nickel alloys in electronic valves, cathodes, grids, anodes, non-magnetic components, support rods and wires, and springs. Illustrated booklet, giving tables of compositional limits of various types of nickel alloys and tables of properties.

Pumps for Heating Systems. RHODES, BRYDON & YOUATT LTD., Waterloo Engineering Works, Gorsey Mount-street, Stockport. Illustrated leaflet describing range of motor-driven floor-mounted Fullway Mopumps, for hot-water heating systems, available in six sizes with flows ranging from 26 gallons to 500 gallons per minute.

Airport Electrification. THE GENERAL ELECTRIC CO. LTD., Magnet House, Kingsway, London, W.C.2. Illustrated brochure describing equipment for airport lighting, ground traffic control, power distribution and lighting control, telecommunications, magnetic sweepers, photo-electric systems, mobile power rectifiers, and general electrical services.

P.V.C. Centrifugal Fans and Ducts. TURNER AND BROWN LTD., Davenport Works, Davenport-street, Bolton. Series of illustrated leaflets giving brief particulars of range of ducting and centrifugal fans in rigid polyvinyl chloride, in capacities from 350 cub. ft. to 15,000 cub. ft. per minute, for corrosive fume extraction.

Industrial Lighting Fittings. HOLOPHANE, LTD., Elverton-street, London, S.W.1. General purpose and heavy duty fittings for low and high bay installations; high bay mercury discharge fittings; technical details in brief and light distribution curves. Illustrated leaflet, publication No. 5503.

Silicone Insulation Tape. DUNLOP RUBBER CO., LTD., Cambridge-street, Manchester, 1. Silicone rubber glass cloth insulation tape in standard widths ½ in. to 2 in., thicknesses 0·008 in. to 0·015 in.; electrical and mechanical properties. Illustrated leaflet.

Tested Electrical Appliances. THE BRITISH ELECTRICAL DEVELOPMENT ASSOCIATION, 2 Savoy-hill, London, W.C.2. List of tested and approved domestic electrical appliances for Local Housing Authorities; covering cookers, driers, kettles, heaters, refrigerators and boilers.

Synchros. THE SPERRY GYROSCOPE CO. LTD., Great West-road, Brentford, Middlesex. Comprehensive catalogue giving specifications of range of Sperry synchros for data transmission. Preceded by discussion of principles. Illustrated with line drawings and graphs.

Sealing Irons. THE ACRO ELECTRIC TOOL MFG. CO. LTD., Chapel-street, Stockport-road, Levenshulme, Manchester, 19. Leaflet giving brief particulars of cellophane-sealing iron and knife-edge sealing iron for welding cellophane, P.V.C., or polythene sheets.

Variable Speed Gearboxes. BOURDON TOOLS LTD., Union-road, Croydon. Illustrated leaflet describing the Omma range of infinitely variable-speed gearboxes of the expanding-pulley type, with or without additional two- or three- speed toothed gearbox.

Air Break Switchgear. A. REYROLLE & CO., LTD., Hebburn, Co. Durham. Air-break switchgear for ratings up to 150 MVA at 3·3 kV. Details of important features, construction, performance and technical data. Fully illustrated pamphlet.

Idler Rollers. BRITISH JEFFREY-DIAMOND, LTD., Stennard Works, Wakefield, Yorks. Idler rollers 4 in. diameter, length from 5 in. to 44 in.; idler nests and complete intermediate sections for industrial and mining duties. Illustrated leaflet.

High Voltage Test Sets. FOSTER TRANSFORMERS, LTD., South Wimbledon, London, S.W.19. Test sets for ratings up to 5 kVA and voltages up to 100 kV. Concise technical details of design and construction. Illustrated leaflet.

Flow-Production of Heavy Diesel Engines. MIRRLEES BICKERTON & DAY LTD., Hazel-grove, Stockport. Flow-production of Diesel engines of all types ranging from 157 to 3,060 b.h.p. Illustrated booklet describing the works and the methods.

Portable X-ray Units. INSPECTION EQUIPMENT, 19 Broad-court, Drury-lane, London, W.C.2. Fedrex portable industrial X-ray units for inspection purposes. Four models 120, 160, 200 and 260 kV. Leaflet.

Grinding, Mixing, Polishing. PODMORES (ENGINEERS) LTD., Pyenest-street, Shelton, Stoke-on-Trent. Leaflet describing briefly Podmore multiple-duty motorised mill for wet or dry grinding, mixing, shaking, and polishing.

Portable Air Dryer. LEC REFRIGERATION LTD., Shripney-road, Bognor Regis, Sussex. Illustrated leaflet giving brief specification of the Lec Moisture Master, capable of removing excess moisture in spaces up to 10,000 cub. ft.

pH Indicator. CAMBRIDGE INSTRUMENT CO. LTD., 13, Grosvenor-place, London, S.W.1. Illustrated leaflet describing the Cambridge direct-reading *p*H indicator covering 0 to 14 *p*H and reading to 0·1 *p*H.

Filtering Dusts and Fumes. THE POWER-GAS CORPORATION LTD., Stockton-on-Tees. Illustrated leaflet describing the Favorit filter process for removing dust and fumes from gases, in which fabric filter sleeves are cleaned automatically by shaking gear.

Compressed-Air Oil and Moisture Extractor. DRUMMOND PATENTS LTD., 5 Great Winchester-street, London Wall, London, E.C.2. Leaflet illustrating apparatus for extracting oil and moisture from compressed air.

Fans and Dust Collectors. PRAT-DANIEL (STANMORE) LTD., Dalston-gardens, Stanmore, Middlesex. Centrifugal fans and types of dust-collector for industrial use. Leaflet No. P33.

Industrial Gloves. G. WADDINGTON & SON LTD., Newland, Hull. Illustrated catalogue of Furno industrial gloves—chrome leather, P.V.C., or rubber—and protective leather clothing for welders.

Stop Valves. CHARLES WINN & CO. LTD., Granville-street, Birmingham, 1. Illustrated leaflet giving specifications of oblique stop valves in cast iron, cast steel and bronze, for steam, water or oil.

50-CYCLE ELECTRIC TRACTION

DEVELOPMENTS IN NORTH-EAST FRANCE

The conference on single phase 50-cycle electric traction, which was held at Lille under the auspices of the Société Nationale des Chemins de Fer Francais from Wednesday, May 11, to Saturday, May 14, gave a large attendance of engineers from a number of countries the opportunity of hearing about the developments which have taken place in the use of this system since the gathering at Annecy in 1951.* In the course of the proceedings some 16 lectures on various aspects of the subject were delivered and the performance of the various types of locomotives, while hauling both heavy passenger and freight trains, and starting and braking on inclines, was demonstrated between Valenciennes and Mohon, a distance of 80 miles.

This section of line forms part of the main route between Valenciennes and Thionville, a distance of 170 miles. It was converted to electric traction about a year ago and it is expected that the remainder will be officially inaugurated at the end of next month. It provides communication between Lille and north-eastern France and Belgium, the Saar and Lorraine, and plans are in hand for extending it both westward and eastward as far as Bale. It includes gradients of 1 in 100 and 1 in 187 and, in addition to express passenger trains, it carries a heavy two-way freight traffic of iron ore and coal, made up of 30 trains a day in each direction with an average gross weight of 925 tons. It was these characteristics which led to its conversion to the 50-cycle system, and there is good reason to suppose that as a result there will be considerable saving in fuel and other economies.

As was brought out at the Annecy conference, the use of single phase current at 50-cycles for traction purposes has the advantages that the necessary power can be obtained direct from the national grid and transmitted at high voltage to the trolley wires. Very few substations are therefore required (there will only be seven between Valenciennes and Thionville) and the overhead construction is lighter, so that it has been stated that the total cost of the fixed installation will be less than half that required for direct-current. On the other hand (and this is the crux of the matter) it is not yet certain which is the most satisfactory electrical equipment to use on the locomotive, owing to the poor commutating characteristics of the 50-cycle motor, although this would provide the simplest arrangement. Various alternative arrangements to overcome this difficulty are therefore being tested on the Valenciennes-Thionville line and as these form the most interesting part of the scheme they are described in some detail below.

BASIC LOCOMOTIVE DESIGN

The locomotives now in use are of two basic types. The first, which weighs 120 tons, has a Co-Co wheel arrangement. It is designed to run at a maximum speed of about 37 m.p.h. and to haul goods trains of 1,800 tons on gradients of 1 in 100, or of 2,400 tons on those of 1 in 166. The second has a Bo-Bo wheel arrangement and weighs 80 tons. It is designed for a maximum speed of 75 m.p.h. and will handle both passenger and freight traffic. The electrical equipment of Co-Co group consists of a motor-generator made up of a single phase motor driving either a direct-current or a three-phase generator, from which the traction motors are supplied. The units forming the Bo-Bo group have either single phase commutator motors or direct-current motors, the latter being supplied through ignitrons.

Mechanically the design of all the locomotives is generally similar to that already adopted on the direct-current locomotives of the French Railways. An interesting modification, however, is the use of a single central cab, which has enabled a considerable saving to be effected on both the electrical control and the braking equipment and simple manual operation to be adopted. Owing to grouping of the control gear and other equipment the driver's work is also rendered easier. The problem of visibility to which a central cab gives rise has been overcome by mounting the two pantographs on an extension of the cab roof.*

* ENGINEERING, vol. 172, page 499 *et seq.* (1951).

ELECTRICAL EQUIPMENT

The electrical equipment of 65 of the Co-Co locomotives which will be employed on the complete line consists of single phase/direct-current motor-generators, the manufacturers of which are Alsthom, La Compagnie Electro-Mechanique, La Compagnie de Fives Lille et La Société-Le Matériel Electrique S.W. On another 20 locomotives it comprises a single-phase/three-phase motor-generator. This latter machine generates three-phase current at a voltage varying between 0 and 1,300 volts and a frequency between 0 and 135 cycles, the equipment for this purpose being manufactured by the Société Oerlikon in association with La Société de Batignolles.

The single-phase/direct-current motor-generators just mentioned consist of a 2,900-h.p., 3-kV synchronous motor, which is fed from the overhead contact wire through a 2,400-kVA transformer and is coupled to two direct-current generators, each of which supplies three traction motors at a variable voltage. Excitation is provided by an Arno convertor which during the starting period acts as an under-compounded generator and supplies one of the main generators. The motor-generator set is run up nearly to synchronous speed and is then automatically connected to the transformer first at half and then at the full line voltage. The traction motors are excited both by a series winding and by a separate winding which is supplied from an auxiliary generator. Speed is controlled by varying the supply voltage to the motors. Regenerative braking is provided. The auxiliaries are driven by three-phase motors which are supplied from the Arno set.

The converting unit on the single phase/three-phase locomotives consists of a synchronous motor, which drives a six-pole three-phase alternator at a speed of 1,000 r.p.m., and an eight pole frequency converter with a speed range of -750 to $+1,280$ r.p.m., which transforms the 50-cycle single phase current into three-phase current at a frequency between 0 and 135 cycles and a voltage between 0 and 1,300 volts. A direct-current generator on the shaft of the first set supplies a motor on the second set at a variable voltage, thus ensuring that the frequency converter runs at a variable speed. This frequency converter in turn supplies six asynchronous three-phase squirrel cage traction motors at variable frequency. The direct-current machine is excited from an Arno set. When the phase converter reaches synchronous speed it is connected to the main transformer through a reactor, which is subsequently by-passed. Regenerative braking is provided. As the six axles of the locomotive are coupled electrically by the frequency it is expected that the adhesion will be good and that wheel slip will not occur.

50-CYCLE SINGLE-PHASE DRIVE

The electrical equipment of the 15 locomotives, which are provided with 50-cycle single-phase motors, was manufactured by La Société des Forges et Ateliers de Constructions Electriques de Jeumont, the mechanical portion being constructed by Les Forges et Ateliers du Creusot. It consists of four 680-h.p. 250-volt traction motors, which are supplied in parallel at a variable voltage from a main transformer. Speed is regulated from the primary side of this transformer, a 20-notch manually operated controller being used for the purpose.

The traction motors have 18 poles and differ in design from the usual alternating current commutator type. The interpole windings can be shunted by resistances and capacitors to improve the commutation, there being three different systems of connection depending on the operating speed. When not being employed as shunts these capacitors can be connected to the transformer, thus improving the power factor. The shunting of the windings is effected electrically, but the other controls are manual. Special arrangements have been provided for cooling the commutators, the result being a considerable gain in simplicity.

* Further details of the mechanical design of these locomotives are given in a paper by F. Nouvion, which was published in the *Proceedings of the Institution of Electrical Engineers*, vol. 101, Part I, page 313 (1954).

THE USE OF IGNITRONS

The five Bo-Bo locomotives on which the single phase current is converted to direct-current by means of ignitrons were also constructed by Les Forges et Ateliers du Creusot, the electrical equipment being provided by Le Matériel Electrique S.W. The output of these units is 3,260 h.p. at 33·5 m.p.h. at the continuous rating and they can exert a continuous tractive effort of 16 tons, which is higher than that of any other French Bo-Bo locomotive that has so far been constructed.

Power supply is through a transformer, the primary voltage of which is controlled by a regulator and thence through eight water-cooled ignitrons with a continuous output of 475 amperes at 750 volts. Each pair of ignitrons is connected to one of the four motors. These motors are of the standard direct-current type, as ripple is reduced to a low value by a choke. They are uncompensated, and field weakening to 50 per cent. of the maximum excitation can be used.

In addition, two high-speed Bo-Bo locomotives equipped with rectifiers of the excitron type and with only one traction motor per bogie have been ordered from Brown Boveri. The advantages claimed for this design are a reduction in the motor weight and improved riding and ventilation. By coupling the axles in pairs an increase in the adhesion should be obtainable and the locomotive should be capable of hauling a train of 1,600 tons up a 1 per cent. gradient.

PARIS-LILLE ELECTRIFICATION

It has been announced that the line from Paris to Lille will be the next to be converted to electric traction on the 50-cycle system. In fact, another 15 Bo-Bo ignitron locomotives have been ordered for this service. These units will have an output of 4,000 h.p., and will be capable of hauling a 700-ton passenger train between the two terminals at an average speed of 75 m.p.h. with two intermediate stops. They will be able to haul a 2,000-ton freight train over the same distance at an average speed of about 40 m.p.h. Finally, it has been decided to construct four dual-frequency locomotives, so as to enable inter-running to take place between the 50-cycle and $16\frac{2}{3}$-cycle systems. Two of these will be equipped with excitrons and direct-current motors and two with single-phase commutator motors. In addition to improving the service ample opportunities will be provided of comparing the performance of locomotives carrying different types of equipment.

Lest this should be considered a disadvantage from the operating point of view, M. Nouvion pointed out during the conference that most of the mechanical parts, auxiliaries, roof equipment and protective and regulating apparatus that have been used are standardised and that these portions of the locomotive represent about 70 per cent. of the total weight. Moreover, standardisation has made it possible to improve the layout of the electrical equipment.

OPERATING RESULTS

The first of each type of locomotive described above, except those equipped with single-phase/three-phase converters, began running at the end of July, 1954, and soon afterwards was hauling trains according to the service timetable. In less than a month after delivery one of the

Bo-Bo locomotives, equipped with ignitrons, started and hauled a 1,500-ton train up a gradient of 1·0 to 1·5 per cent. at a speed of 32 m.p.h., while a Co-Co locomotive, equipped with direct-current motors, drew a 1,850-ton train up a gradient of 1 per cent. Although the number of electric locomotives so far delivered does not enable full use to be made of their capabilities, loads of 1,050 tons, 1,400 tons and 1,850 tons, respectively, are being hauled over the undulating section between Valenciennes and Lumes by the Bo-Bo locomotives with 50-cycle motors, the Bo-Bo locomotives with ignitrons, and by the Co-Co locomotives with single-phase/three-phase equipment. In this connection, it is interesting to note that M. Nouvion stated categorically that the 50-cycle locomotive is much superior to any other, even to those of the 1,500-volt direct-current type, while M. Tessier made a special plea in favour of those equipped with rectifiers.

POWER SUPPLY

Power for operating the Valenciennes-Thionville line will be eventually obtained from seven substations, which will be supplied from the network of Electricité de France through duplicate lines. These substations are generally sited near the substations of the supply authority. At Fourmies, Mohon, Chauvency, Joudreville, Herserange and Thionville the primary voltage is 62 kV and at all of them, except Herserange and Valenciennes, there will be two Scott-connected transformers, one of which is reserve, giving a single-phase voltage of 22 kV at the contact wire. At Valenciennes the primary voltage is 45 kV.

This equipment is usually installed out of doors, the layout being generally similar to that adopted on the 1,500-volt line between Lyons and Culoz. Remote control is effected from a small building, which also contains the usual relays, alarm panel and battery. The transformers themselves are mounted on trucks on which they can be moved into the working position.

A central control station has been built at Charleville, about the centre of the electrified section. This is equipped with the usual miniature apparatus which is also similar to that used for the control of the latest 1,500-volt direct-current substations.

OVERHEAD EQUIPMENT

The Scott transformers are connected through switchgear to the catenary system. As the result of the experience gained on the Aix-les-Bains/La Roche-sur-Foron line, the catenary system is of polygonal construction, since this can be more easily adjusted and requires less upkeep. The insulators, which are of the rod type, are fixed close to the supporting columns instead of over the axis of the track, so that they are not exposed to the exhausts of steam locomotives. It has also been possible, as the result of experience, to reduce the amount of insulation between the catenary and the steelwork as well as between the catenary and the conductors.

Owing to the introduction of 50-cycle traction, a number of modifications have been necessary in the communication circuits, in order to avoid trouble from interference. All the signal circuits have been placed underground and the wires to mechanically operated points and signals have had their metallic continuity broken at the entrance to the boxes and at intervals along the track by separators of insulating material. The lever frames have also been earthed.

The block system has been modified to protect it from induction. Between Avesnes and Montmedy, where no stray currents have been detected, only one running rail is insulated and direct-current track circuits are employed. On the remainder of the Valenciennes-Thionville section, where automatic block working is employed, the track circuits are supplied with 83⅓-cycle alternating current through both running rails.

At Avesnes station an experimental system of 1,000-cycle track circuiting was installed and has been so satisfactory that it will probably be exclusively employed in future in the north-eastern region.

Institution of Naval Architects Spring Meeting (*continued from page* 623)

LINERS FOR FAR EASTERN SERVICE

TECHNICAL AND ECONOMIC CHANGES IN 50 YEARS

On the conclusion of the annual general meeting, reported separately elsewhere in this issue, the technical sessions were resumed. The President continued to occupy the chair, and Sir William Currie presented his paper on "Liners of the Past, Present and Future on Service East of Suez."

COMPARISON OF THE MARMORA (1903) WITH THE ARCADIA (1954)

The paper consisted mainly of a comparison, economic as well as technical, between two vessels of the Peninsular and Oriental Steam Navigation Company, of which Sir William Currie is the chairman; namely, the Marmora of 10,509 tons gross, built in 1903, and the Arcadia, of 29,734 tons gross, which went into service in January, 1954. In his introduction, however, Sir William mentioned that the first vessel to pass through the Suez Canal from North to South, on November 17, 1869, was the P. & O. liner Delta, of 1,616 tons gross; she carried 126 first-class and 50 second-class passengers, and 800 tons of cargo, and was propelled by paddles, driven by an oscillating engine working with steam at a pressure of 20 to 25 lb. per square inch, which gave her a speed of 14½ knots.

The Marmora was 530 ft. in length between perpendiculars and the Arcadia, 668 ft. Their other leading particulars were, respectively: breadth, 60 ft. and 90 ft. 6 in.; depth to bulkhead deck, 37 ft. 3 in. and 40 ft.; displacement (loaded), 16,243 tons and 31,846 tons; block coefficient, 0·674 and 0·592; midship area coefficient, 0·926 and 0·970; horse-power of propelling machinery, 10,500 indicated and 42,500 (maximum); weight of machinery, 2,054 tons and 2,895 tons; boiler pressure, 215 lb. and 530 lb. per square inch; electrical installation, 92 kW. and 3,600 kW.

The Marmora carried 377 first-class and 187 second-class passengers and a complement of 365, of whom 131 belonged to the engine department; her boilers were, of course, coal-fired. The Arcadia has accommodation for 679 first-class and 735 tourist passengers and has a complement of 704, of whom only 81 are in the engine department. The Marmora carried 2,080 tons of coal and consumed 121·7 tons per day at 15 knots; the Arcadia, 4,300 tons of oil, consumed at the rate of 167 tons per day for 20 knots speed. The Marmora required only 20 tons of water per day; the Arcadia uses 350 to 450 tons per day. The Marmora's 22 lifeboats could carry 940 persons; the 22 boats of the Arcadia, 2,176 persons. The first costs were, respectively, £250,000 and £6,500,000; dock and labour charges for entry into London Docks, £392 18*s.* 6*d.* and £2,984; average annual cost of port dues, light dues, pilotage and towage, £2,022 and £15,000; annual cost of repairs and maintenance, £4,482 and £82,600. The first cost, annual outlay and annual earnings, per ton of displacement, were, respectively, £18 8*s.*, £11 5*s.* and £29 for the Marmora, and £207, £36 5*s.* and £69 for the Arcadia.

Looking to the future, Sir William Currie said in conclusion, it seemed that the principal advances would be in the production of more efficient propelling and auxiliary machinery. Sea and air, he thought, were complementary, and it would be wrong to conclude that, because 50,000 people travelled by air during a given period, they represented a loss of 50,000 passengers by sea; many of them would not have travelled at all if they had not been able to go by air, and others were lost to rail transport only.

DISCUSSION: FIRST COST AND EARNING CAPACITY

Sir Charles S. Lillicrap, K.C.B., in opening the discussion, referred to Sir William Currie's observation that there had been no spectacular improvement in shipbuilding such as there had been in aircraft development, nuclear physics, electronics, etc. The reason was not far to seek; many years ago, the sound scientific basis of ship design had been settled by the researches of Froude and others; the results of their researches were implemented, and consequently all that could be done to-day was to reap small advantages here and there. The newer industries were still in their infancy and their rate of progress in the future would certainly not be so spectacular as in the past few years.

In the section of the paper dealing with finance, there were some startling and disturbing figures. The earning capacity of the Arcadia appeared to be eight times that of the Marmora, which seemed very good until the figures were examined in detail; then he was left wondering how long the liner could survive. The first cost of the Arcadia was 26 times that of the Marmora; the costs of repairs and maintenance were 18 times as great, and the other items, though not so startling, were impressive enough. There seemed to be a mystery there which Sir William had not explained. Coming to technical matters, he noticed that there is no camber to the lower decks of the Arcadia; why was camber omitted from those decks?

The ratio of steel weight to displacement of ship was 0·351 for the Arcadia, whereas for the Marmora it was 0·396, but the weight of the hull as compared with displacement was 0·575 in the Arcadia as against 0·529 in the Marmora. Was that another indication of the multiplicity of fittings and equipment in a modern liner? It seemed that the naval architect had saved steel, only to have the saving swallowed up by equipment which would not have been carried in earlier days.

He had noted that the Marmora was fitted with hydraulic cranes for handling cargo, but in the Arcadia the lifting appliances were derricks, and he wondered why that change had been made. In the Royal Navy the tendency was to substitute cranes for derricks and winches. He agreed entirely with Sir William's view that the air was never likely to provide a complete substitute for sea transport.

INCREASED BEAM FOR GREATER STABILITY

Sir James M. McNeill, F.R.S., said that the paper was obviously designed for a much larger circulation than could be given to it in the *Transactions* of the Institution. It presented many facts which were worth pondering and it was fair in its comparisons. He agreed with the author that progress in shipping over the past half century had been comparatively small in relation to that in many other industries; but in relation to the other main form of transport, namely, railways, it had made vast strides in every one of its essentials, and many modern inventions had been superimposed on ships' equipment as compared with 50 years ago, or even 25 years ago. The latter period was probably much nearer to the average lifetime of a passenger vessel. The author stated that one reason for the "beamier" ship of to-day was the greater margin of stability now required in passenger liners. That had been a very obvious requirement since the promulgation of the 1948 Safety of Life at Sea Convention; the amount of work that was involved now in dealing with transverse subdivision and in complying with all the requirements of the Convention undoubtedly had driven them to greater beam. Even since 1948, the beam had increased and the naval architects had to be careful to ensure that the beam was adequate to meet all those requirements; that must be done

in the initial stages. In addition to satisfying the statutory requirements governing fire detection and extinguishing, they must also provide more subdivision of accommodation, safeguard stairways, provide additional escapes, etc., and in a ship of the type of the Arcadia that inevitably meant a reduction of revenue-producing space. Evidently, Sir William Currie had a great respect for Father Noah. Taking the cubit as 18 in., the dimensions of the Ark were something like 450 ft. by 75 ft. by 45 ft. By the end of the present century the maximum dimensions of ships would probably approach those ratios. One means of solving the shipping problem from the economic point of view must be a still further increase in beam and still further efforts to achieve the maximum revenue-earning space within the shortest possible length and the lowest possible first costs.

ORDERLY VERTICAL PLANNING

Sir Colin S. Anderson said that he would speak from the point of view of the customer of the naval architect. One thing that they should try to arrive at in the design of large passenger ships was a more orderly arrangement in the vertical planning of accommodation. He felt sure that the shipowner was to blame for the present situation; he seemed to demand a different kind of cabin on deck A from that on deck B, yet another type on deck C and so on, which made it difficult to plan the runs of electric leads and other things. In a modern hotel or block of flats, each room on the first floor was similar to the corresponding room on the eighth floor. The ease of construction which could be effected if they could get something of that sort into liner design would be extremely welcome.

With regard to derricks *versus* cranes, a simple reason for using the derrick was that it retained one prime facility which a sea-going crane could not be expected to have, namely, it would cover a far greater area laterally. On a large ship that was important, particularly when working over both sides simultaneously, and perhaps over barges as well.

A matter which gave much food for thought was the use of aluminium; whoever could make use of it in a large liner, as it could be used, would reap advantages. It would be necessary to consider, however, whether aluminium, when coated with fire-resistant materials, would not have a weight approximating to that of steel. Another problem which was becoming more and more difficult in liner design was that, as the speed increased, what used to be considered a pleasant breeze when sitting on deck became an intolerable hurricane. No longer could one sit on the promenade deck of a modern liner, even going into still air, and they had to give a lot of thought to the creation of wind-free or draught-free pockets of fresh air on deck. Much money had been spent on the exploration of new notions for driving aeroplanes, and out of that should come opportunities to learn new lessons which could be applied to ships' engines. The fact that the newest aeroplane could work up to a shaft horse-power equal to that of a 30,000-ton liner within a few seconds, whereas to do that in a liner took two hours, led him to suppose that there was something to be studied in that. The Southern Cross was an example of how much there was still to do.

DIFFICULTIES OF REPAIRING MODERN SHIPS

Mr. H. A. J. Silley, President of the Institute of Marine Engineers, said that Sir William Currie's comparison of the Marmora of 50 years ago and the Arcadia of to-day showed how the modern vessel had grown not only in size, but also in complexity. That affected the ship repairer, because modern liners, with their increased beam and considerably increased draught, required very much larger dry docks, a problem that was exercising the ship-repairing industry very much indeed. Recently, his firm had been preparing some figures of the cost of enlarging a dock; to enlarge a dock 550 ft. ong and 60 ft. beam to about 800 ft. long and 100 to 110 ft. beam would cost to-day more than the building of three docks would have cost in the period from 1918 to 1939. Sir James McNeill had referred to the ratio of dimensions of the Ark and the possibilitity of the ships of the future moving towards that ratio. Mr. Silley hoped he was right, because they had been working on that basis in designing the dimensions of their dry docks. They had to deal with the tanker, with its enormous increase of beam over the past few years; with ships of the Arcadia class, the draught of which, even in the light condition, was greater than that of the tanker in the almost loaded condition; and they had to consider dealing with stabilisers, and the additional beam required in dry dock when refitting, repairing and inspecting them. Also, in ship repairing, they had to provide services arising out of the developments of the past quarter or half century, to employ specialists in the various trades, and to install more expensive and complicated machinery to-day as compared with the days of the Marmora.

The paper referred to the special problems associated with welded hulls, and the prevention of corrosion of structural steel. The ship-repairing industry was keeping as up to date as it could in those matters. There was an ever-increasing desire on the part of owners for special treatment of their ships' hulls in dry dock, and it was a matter for regret that in this country, at the moment, they could not give the service which could be obtained abroad, particularly in the United States, for the sandblasting of ships' hulls. That matter was being very carefully considered, but they were up against questions of resistance by labour, and all kinds of regulations, Home Office and Factory Act requirements, which made the advance into those fields rather slow and extremely difficult. His own firm had been carrying out experiments and were working in conjunction with another firm on the design of some equipment to meet all the difficulties and objections.

UNIONS RESTRICT PRODUCTIVITY

Mr. K. C. Barnaby, O.B.E., commented on the fact that, while annual earnings had gone up only about 2·4 times per ton, first cost had gone up 11 times. If the nation's life-stream was not to become too attenuated, the builder must make every effort to combat those spiralling costs. Many of them, of course, were outside his control, but building costs could be reduced greatly by increased productivity. That did not need longer hours or harder work, but it did involve greater readiness to adopt new methods, and to abandon restrictive practices and the eternal internecine warfare between different trade unions. It was claimed by union officials that the admittedly high standard of craftsmanship of the British worker was largely due to the specialisation involved by so many unions. It was difficult to concede any truth in that statement when confronted by two unions, each claiming that their men alone were the only people qualified to undertake some new but perhaps quite trivial job.

The author struck what must be, to old P. and O. passengers, a slightly nostalgic note when he spoke of public rooms "furnished with fabrics of somewhat subdued colours." In the absence of mechanical ventilation and air-conditioning, every effort was made to keep down heat and glare; hence also the black topsides and drab yellow superstructures. Sir William Currie had dealt very adequately with the numerous technical improvements introduced in recent years, but there was one change he had not chronicled. In the Marmora era, the smoking room was the privileged habitat of the male. Ladies had to drink with discretion and due decorum in the dim recesses of the "Divan," a sort of hinterland between the smoking room and the lounge, as it was now usually called. A favourite name for that apartment on liners of the period was the horrid and often erroneous term of "Social Hall." In the Arcadia it was the "Drawing Room," but even that title was a little forbidding for the modern cruise passenger.

PROGRESS IN MARINE ENGINEERING

Mr. J. Lenaghan said that the change during the past 50 years which had impressed him particularly was the great increase in electrical power on board ship. That was a major increase in naval ships also, and there was evidence that in passenger liners the electrical load would continue to increase. On the engineering side there had been far more progress than on the side of naval architecture. The machinery horse-power per ton weight in the Marmora was 5·1 and in the Arcadia it was 11·75, which suggested that the modern ship produced more than 2·3 times the power per ton of machinery working. Machinery changes undoubtedly were a sign of progress, but they presented many problems. In two exactly similar ships built for different owners, the horse-power being the same in both cases, the difference in machinery weight was roughly 800 tons. In working on the same design with such a difference in machinery weight there were many problems, particularly problems of stability. That brought him to the questions of stability and the Ministry of Transport requirements for compliance with the two-compartment standard of sub-division. The Ministry did not force the designer to adopt the two-compartment standard; but they quietly guided him towards it—and there was another 3 ft. on the beam!

STABILISERS: FRESH WATER

Stabilisers had become essential to offset discomfort to passengers resulting from higher G.M.; but the stabiliser was still in its infancy and he did not think that the present type of stabiliser would have a long life. He did not know what the next step would be; but, as an alternative to the present type of stabiliser, they might have to consider certain changes in form, and if that meant larger beam the question of stabilising would become of great importance. He wondered whether something on the jet principle could be introduced to offset rolling, or screws on each side, built into the hull.

One extraordinary comparison was the difference in the consumption of fresh water on the two ships; the Arcadia used almost ten times the amount of fresh water than the Marmora used, on the basis of the numbers of crew and passengers. If the consumption of fresh water was as high as was shown in the paper, evaporators were essential; but whether the fresh water was provided by evaporators or taken on board at various ports, it was certainly a very expensive item.

Captain J. P. Thomson, O.B.E., observed that fuel consumption was the biggest item in running vessels like the Arcadia. His own first command was in 1918, when the fuel consumption per i.h.p. was 1·45 lb.; to-day the sister ship of the same name consumed 0·4 lb. of fuel per i.h.p. Sir Colin Anderson had referred to camber. In tankers, camber and shear made very important contributions to seaworthiness, and he would not see either sacrificed. Shear was going, to some extent, but he hoped the shipbuilders would call a halt to that. He inquired whether there was any economy in fuel to be set off against the cost of fitting stabilisers. Concerning the use of aluminium, sailors would like to see more of it used in the superstructure, particularly surrounding the magnetic compass.

Mr. E. L. Champness, M.B.E., said that it was very helpful for shipowners to come to the Institution and indicate their requirements. References to costs might well be accompanied by a table showing the changes in the value of the £ over the years; then shipowners would find that they were really getting a lot more for their equivalent £ than appeared from the figures of first cost in the analysis. The author had said that one of the crying needs was for the shipbuilder to have a period of stable costs; perhaps he would agree to go further and to say that possibly the greatest need at the moment was a period of stability of the £. The technical personnel in the crew of the Marmora numbered 213, whereas in the Arcadia, a much larger ship,

the skilled personnel numbered only 177. The reasons for the reduced number of personnel were largely the technical achievements of the shipbuilder and the engineer in the period concerned. The paper referred to maintenance and running costs, in which connection he drew attention to the enormous and very speedy increase in resistance arising in the Lucy Ashton tests, and a corresponding rise in fuel costs. When the problem of fouling or corrosion was solved by scientific means, chemical or otherwise, it might be that the operational routine of dry-docking mentioned in the paper, might have to be revised; it was a question of economics.

Sir Stanley V. Goodall, K.C.B., recalled that Sir William Currie had stated that the progress made in shipping over the past half-century was comparatively small; but the horse-power of the new ship was four times that of the old, the weight of machinery was only 40 per cent. greater, the length of the engine room was 15 per cent. less, and the number of men employed to work the machinery was only two-thirds of the number so employed 50 years ago. That was a remarkable achievement, and it was only right that naval architects should pay tribute to the marine engineer for having accomplished it.

PASSENGERS AND CARGO

The President said that he had been greatly interested in the comments made concerning costs and earning capacity in the comparison of the two ships. Most shipowners did not think of their ships in terms of a single ship, but in terms of a fleet; one ship, by herself, would be nothing like so successful as she would be as one of three ships operating a circuit. That was an elementary point. Passengers were a form of cargo, a particularly difficult, perishable and, unfortunately, vocal cargo but fundamentally the economics were the same. The question was simply whether the "freight rate" would justify the increased facilities that must be provided in order to get the traffic. In all those things, the shipowner was guided to some extent by what his competitors were doing. He must constantly build a faster and more expensive ship, even if, at first sight, he did not see the same earning capacity in it.

Secondly, quite a number of people engaged in the carriage of passengers, not primarily because they thought that passengers as such provided their principal source of revenue, but because the fact that they carried passengers often helped in the running of their cargo ships. It was not merely that the great passenger liners and their owners were in the public eye and so were, in the best sense of the term, of publicity value, but also they guaranteed to the cargo shippers certain qualities of regularity and speed. He thought that, in the future, the problem in the design of passenger liners would be increasingly that of combining passengers with other forms of cargo. That offered a great deal of scope for the naval architect. There was a suggestion some time ago to provide an opening in the side of a ship for the admission of cargo, instead of lifting it and dropping it down in the middle. If large storerooms could be built under Sir Colin's blocks of vertical flats, they would have considerable advantage. On such lines there seemed to be room for considerable development, and they should be grateful to Sir William Currie for having shown, by his comparison of two ships, what the limits of extrapolation might be in that respect.

Sir William Currie replying to the discussion, said that some of his firm's shareholders had said that they should not build ships at extravagant prices. If they had not done so since the war, however, he did not know where their trade would be to-day. Further, if they had not built ships since the war, but started to build them to-day, they would have had to spend about £7 millions more. The change to white paint for the hulls of passenger ships had made a difference of 3 or 4 deg. F. inside.

The other points raised would be answered in writing.

(*To be continued*)

Iron and Steel Institute Annual General Meeting (*continued from page* 625)

OPEN-HEARTH FURNACE CHARGING

INVESTIGATION OF BUNCHING DELAYS IN FEEDING SCRAP TO FURNACES

The second technical session of the recent two-day annual general meeting of the Iron and Steel Institute, held in the afternoon of the first day, Wednesday, April 27, was devoted to the presentation and joint discussion of two papers dealing with open-hearth furnace charging.

FURNACES READY SIMULTANEOUSLY

The first paper, by Mr. R. Solt, of the operational research section of the British Iron and Steel Research Association, dealt with "Charging Delays due to Furnace Bunching." He stated that there were in all melting shops frequent occasions when a number of furnaces became ready to be charged at the same time or in rapid succession. When such "bunching" became severe it might be impossible to supply scrap to the furnaces at the rate at which they were demanding it. The investigation of the subject had now enabled a measure of bunching to be defined in terms which would allow the demands of the furnaces to be related to the capacity of the charging system. This made it possible to determine the total charging delay that would be suffered by a melting shop under existing or proposed conditions.

The second paper, entitled "The Supply of Scrap to Open-Hearth Furnaces," was by Mr. M. D. J. Brisby and Mr. W. O. Pendray, and also represented work carried out by the operational research section of the Research Association. It was presented by Mr. Brisby. The authors stated that little could be done to prevent bunching, but heavier pan weights and better supply services could go a long way to reducing delays. Inward scrap should be carefully examined and marshalled by grade. Scrap should never be put to stock indiscriminately, especially in a loading bay. The delay suffered from charging bad scrap for a period more than outweighed the time saved by subsequently charging heavy scrap; light and heavy scrap should be loaded, therefore, in fairly rapid succession. Furthermore, wherever possible, overall pan weights should be increased by dropping heavy material, such as mill scrap on top of shearings and similar light materials.

Since bunched charging and slack periods alternated, the slack periods must be utilised to build up the largest possible stock of scrap for the next period of bunched charging. This required careful management of bogie traffic and loading operations. Empty bogies must be removed from the stage as soon as possible after charging and returned straight to the scrap shed for reloading. It was quite as important to load scrap as it was to charge it, and empty pans must be taken to the loading bays just as urgently as loaded pans to the furnaces.

A small number of bogies loaded with particularly heavy scrap should be set aside as a reserve for use only during emergencies, such as periods of particularly severe bunching or lengthy traffic hold-ups.

BUNCHING INEVITABLE?

Mr. W. Evans, who opened the discussion, said that Mr. Solt's paper dealt with an ingenious mathematical treatment of the probability that certain delays due to bunching would occur, but the paper did not offer any remedies. Every open-hearth operator, to his cost, knew that bunching occurred. A great deal of thought had been brought to bear on the problem of how it could possibly be avoided, but unfortunately most operatives had come to the conclusion that the only means of avoiding bunching involved eventually a loss in production, which was a most important point.

As it was recognised that bunching did occur, more machines and more facilities had to be provided for doing the work in the shop than were absolutely necessary to enable the heats to be tapped in a regular manner. Thus, the number of cranes and soaking pits generally associated with a given steel production was considerably larger than was strictly necessary. Moreover, open-hearth furnaces were tending to become larger and this tended to make the problem of bunching worse.

In other processes of making steel, such as the Bessemer converter or the electric furnace, it was possible to arrange to get batches of steel to the soaking pits in a reasonably regular and continuous manner and the batches were not quite so voluminous as they were with the very large fixed furnaces. The large open-hearth furnaces were leading steel producers at present, and if the shop manager could get the maximum amount of scrap into his charging boxes there was not a great deal more that he could do. This brought to the fore the whole question of scrap quality and grading, and suggested that a better method of assessing the value of scrap was to pay for it on its density. That must be the desire and object of all open-hearth managers, namely, to double or even treble the quantity of scrap which could be got into a box. By this means the problem of bunching would not be eliminated but, at least, it would be alleviated.

ORGANISING THE DELIVERY OF SCRAP

Mr. C. H. Bacon said that his firm, John Summers and Sons, Limited, were in close agreement with the recommendations put forward in the second paper. Their organisation for the delivery of scrap to the furnaces had recently been strengthened and now included one man who was responsible for the movement of traffic from the scrap sheds to the furnaces. He worked very closely, on the one hand, with the scrap-shed foreman and, on the other hand, with the materials checker, who was responsible for the allocation of scrap and other materials, such as limestone, to the furnaces.

They were also paying very special attention to the question of bogie return times and were trying to reduce these to the absolute minimum. They had found, moreover, that they had been able to increase the weight per pan from an average of 26 cwt. to an average of 32 cwt. by the careful mixing of light and heavy scrap, this having been made possible, to some extent, by a general improvement in the scrap received.

Mr. J. H. Flux said that there was a tendency to consider a bundling press just as a piece of plant which handled thin sheet material. The press must be looked upon as a means of handling the medium heavy scrap which formed the bulk of present-day supplies. If such a press were fed by means of a conveyor, which could be used as a sorting belt to reject extra heavy material, the difficulty of over-sized scrap jamming the press would not arise and it should be possible to obtain bundles giving a pan weight of from 2 to 2½ tons instead of the 10 cwt. to 15 cwt., obtained by filling medium-heavy scrap loose into the pan. That meant a considerable reduction in the number of pans to be handled, which would help the general supply system.

It might be objected that a bundle of this size would be difficult to melt, but he did not think such to be the case, because its density would be less than that of a bale obtained by pressing thin sheet material.

(*To be continued*)

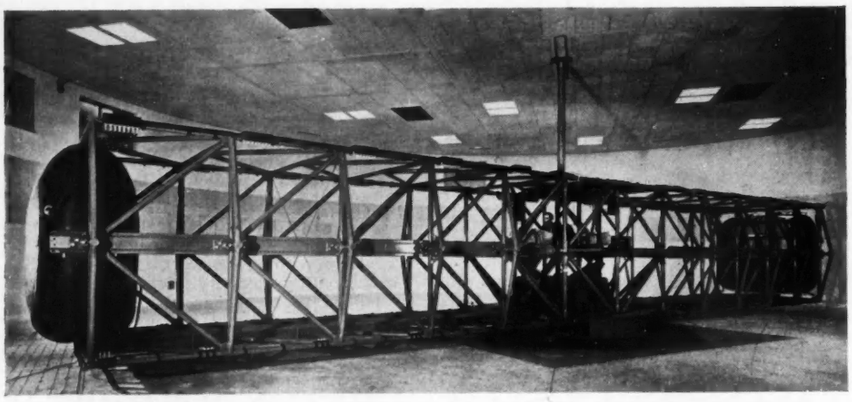

Fig. 1 The man-carrying centrifuge at Farnborough. The subjects seated in the trunnion-mounted cars are watched continuously by observers, seated at the centre of the rotating arm.

MAN-CARRYING CENTRIFUGE

RESEARCH APPARATUS AT R.A.F. INSTITUTE OF AVIATION MEDICINE

The man-carrying centrifuge at the Royal Air Force Institute of Aviation Medicine, Farnborough, recently inaugurated by the Air Minister, is designed to simulate the centrifugal acceleration encountered by pilots when they change direction at high speeds, and to provide means for measuring the physiological reactions to such accelerations. It is believed to be the largest and, in respect of instruments, the best equipped machine of its type in Europe.

The main contractors for the centrifuge were M. B. Wild and Company, Limited, Birmingham; all the electrical plant was supplied by the General Electric Company, Limited, Magnet House, Kingsway, London, W.C.2.

MAXIMUM ACCELERATION 30*g*

The centrifuge (Figs 1 and 2) consists basically of a horizontal arm rotating under a precisely-controlled cycle of acceleration and deceleration which can be accurately repeated any number of times. The arm, which is 62 ft. 6 in. long and comprises a centre section built up in high-tensile steel tube and end sections of high-tensile light-alloy construction, has a car suspended at each end, and is mounted on a 12-ton flywheel attached to a vertical-spindle driving motor installed in a central pit of the centrifuge chamber. The cars were supplied by M. L. Aviation Company, Limited, White Waltham, Berkshire, and the fabrication of the rotating arm was carried out by Air Service Training, Limited, Hamble. Each car weighs 1,150 lb. and, mounted at the ends of the arm, as illustrated, they can attain a maximum peripheral speed of 115 m.p.h., at which the centrifugal acceleration is equal to 30*g*. Normally, when human subjects are being tested, the centrifuge is restricted to a maximum of 10*g*, but this can be safely increased to 12*g* or 15*g* when the subjects are in prone positions. The arm is also capable of rotating two heavier box cars, each weighing 3,300 lb., at 66 m.p.h., the maximum acceleration then being 10*g*.

The rate of change of acceleration is governed by the rate of change of motor speed, and the control arrangements provide for increasing the speed to give the required acceleration in 9, 12, 18 or 30 seconds by means of interchangeable cams. Each car is mounted on trunnions, fore and aft, so that it can swing out to maintain the direction of the resultant acceleration on the subject unchanged as the centrifuge speeds up. Hydraulic dampers are provided to check any tendency of the cars to over-swing or oscillate. The speed of the motor is varied, in accordance with the programme required, by the electrical control gear. The arm is provided with attachment points for the cars at radii of 10, 15, 20, 25 and 30 ft.

The centrifuge can be operated either automatically or manually by a controller seated at his desk in the control room, or by either of the two subjects in the cars. When the two subjects are jointly controlling the speed, the mechanism is arranged so that the speed automatically follows the lower setting, while in an emergency the arm can be brought to rest by the controller, by the subjects or by observers seated at the centre of the arm on either side of the driving spindle. The observers travel round with the centrifuge and have a clear view of the subject through the Perspex roofs of the cars.

To ensure the safety of the subjects and of the mechanical structure, the severity of any run is never allowed to exceed that of a test cycle primarily laid down by the Institute of Aviation Medicine. This specifies the maximum speed of the centrifuge and also the maximum rate of change of speed at any speed.

For certain types of tests, it is possible to remove the cars and, in place of them, erect at the ends of the arm box-like structures of high-tensile light-alloy construction lined with foamed rubber. These enable experiments to be performed on the effects of comparatively low accelerating forces on the ability of subjects to perform simple feats involving movement, such as putting on parachute harness. They also enable tests to be carried out on aircraft and guided-missile instruments and components.

TESTING HUMAN SUBJECTS

The normal operating team consists of a controller, observer, recorder and the subjects in the car. The rate of acceleration or deceleration can be controlled manually by the subject—if he feels that the *g* is getting beyond endurance—or by the controller, using a standard "joystick."

Controller, recorder, observers and subjects, are all provided with means of stopping the arm in case of illness or emergency, and in addition, the controller has an emergency push-button, which cuts off the electricity supply entirely, and brings the arm to rest by the application of the mechanical brakes. The subject is always in communication by microphone and loudspeaker with the observer, who in turn is in two-way communication with the controller and the recorder.

The reactions of the subject—pulse and respiration rates, blood pressure and heart and

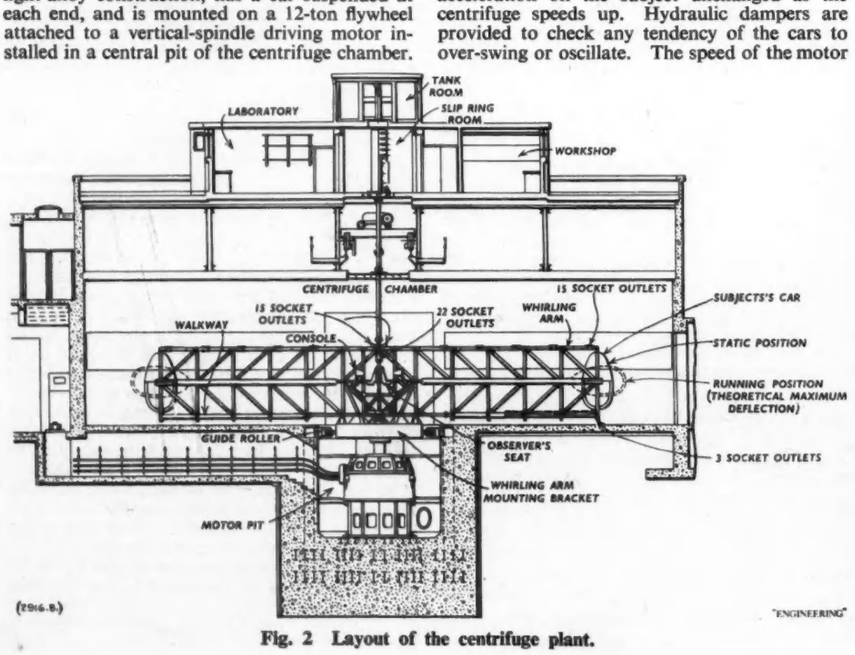

Fig. 2 Layout of the centrifuge plant.

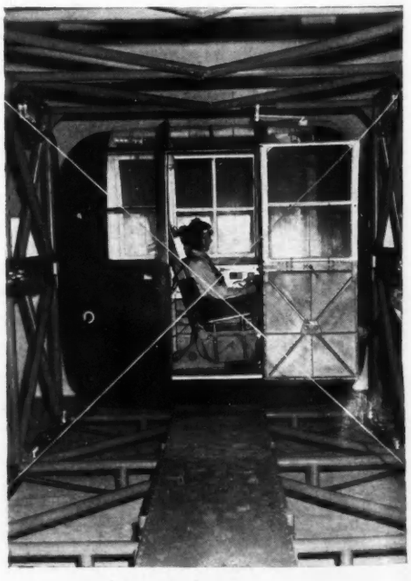

Fig. 3 The subject seated in one of the cars. Electrodes are attached to his body to record his reactions.

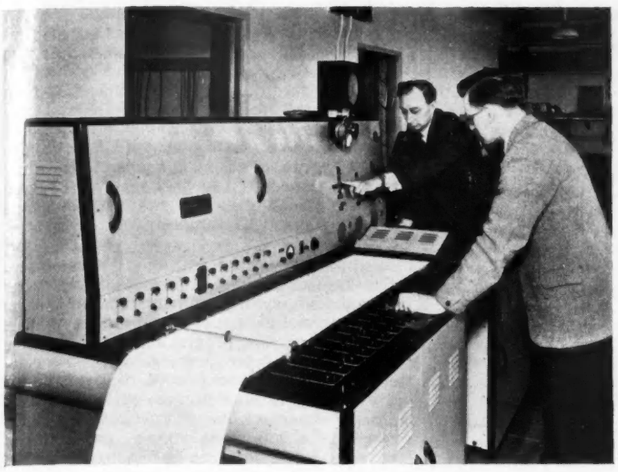

Fig. 4 The recording room, showing the 12-channel electro-encephalograph pen recorder.

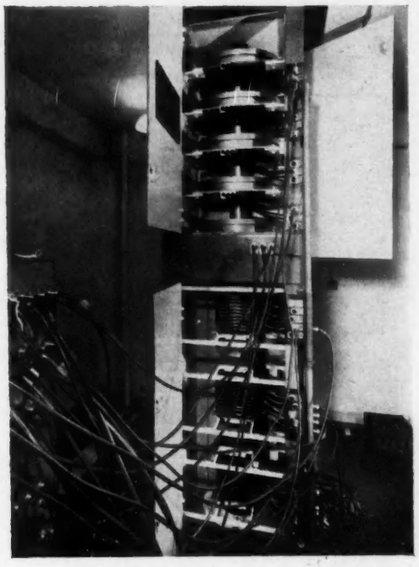

Fig. 5 The slip-ring column for the electro-medical and Teletalk circuits.

brain functions—are recorded electrically from electrodes attached to his body (Fig. 3), the wires being run from the car, along the arm, up through a hollow shaft in the centre of the arm which extends to a slip-wing column in the roof near the recording room (Fig. 4). Reactions are indicated either as curves photographed in an 18-channel photographic recorder supplied by Films and Equipments Unit, 138 Wardour-street, London, W.1, or as graphs drawn by an Edison-Swan 12-channel electro-encephalograph pen-recorder. The amplifying equipment was supplied by Southern Instruments, Limited, Camberley.

The extreme sensitivity of the measuring equipment makes recording a very difficult operation, easily spoilt by outside electrical influences. For this reason all the conducting wires are screened with a flexible earthed metal sheath. Many of the rooms in the building above have been completely screened by covering the walls, floor and ceiling with copper mesh, and the doors covered with sheet copper. The screening is believed to be the most effective of any centrifuge in the world.

PLANT AND CONTROL GEAR

The main driving motor has an overall weight of 46 tons; it is supported on a stool which houses an extension shaft carrying a group of 24 sliprings for providing circuits to the rotating structure for control purposes, lighting and experimental use. The connecting cables pass through the hollow shaft of the motor up to the arm. Half of the sliprings are rated at 60 amp. and the remainder at 30 amp. The motor is fitted with a 12-in. diameter ball-thrust bearing of the angular contact type, and with a top roller guide bearing 17¼ in. in diameter. The motor is rated at 1,350 h.p. at 54 r.p.m., maximum power being developed at the end of acceleration. A gearbox of ratio 3 to 43 is directly coupled to the motor shaft extension below the sliprings. The high-speed shaft of the gearbox drives two tacho-generators and three overspeed devices. Two Magslip transmitters are also driven from the motor-shaft extension through reduction gears of ratio 2 to 1.

ELECTRO-MEDICAL SIGNALS TRANSMITTED THROUGH SLIP-RINGS

A separate slipring column (Fig. 5) is mounted above the arm in a room over the centrifuge chamber. This column is directly coupled to the arm and is fitted with 60 silver sliprings and 30 mercury troughs for the various electro-medical and Teletalk circuits. The sliprings are divided into three banks of 20 rings, and the mercury troughs into five banks of six troughs arranged in pancake form. Two silver-carbon brushes are provided for each slipring, and a spade-type collector for each mercury trough.

Owing to the exceedingly low level of signal strength expected in some of the electro-medical recordings, special care has been taken to reduce the possibility of extraneous interferences entering these circuits. The wiring is carried out in individually-screened twisted pairs.

The control desk, the amplifier for the Teletalk equipment and a cam unit which controls the cycle of acceleration and deceleration, are housed in a control room (Fig. 6) which has a window giving the controller a clear view of the rotating arm in the centrifuge chamber. The control column is mounted in front of the desk. The centre portion of the desk is equipped with a motor speed indicator and a g meter showing the acceleration to which the subjects in the cages are being subjected; the side wings house the various control switches, instruments and relays and also the control equipment for the Teletalk apparatus. The cam unit, behind the controller, contains the main control potentiometers and the driving gear for the associated cams, and is fitted with a hinged top cover to facilitate cam changing. It is shown with covers removed in Fig. 7.

The main control board containing the contactors, relays and general protective equipment, in addition to the electronic speed-control apparatus, is housed in a plant room in which is also a motor-generator set which supplies power to the main driving motor. A cable tunnel runs from the plant room to the motor pit in the centrifuge chamber.

The motor-generator set consists of a direct-current generator with a maximum rating of 1,950 kW at 760 volts, driven at 980 r.p.m. by a 1,250-h.p. induction motor connected to a 6·6-kV three-phase supply. The exciter for the field windings of the centrifuge motor forms part of the same set, and is rated at 10 kW at 220 volts.

The Teletalk apparatus comprises two separate

Fig. 6 The control room. Behind the controller is the cam unit controlling the rate of acceleration.

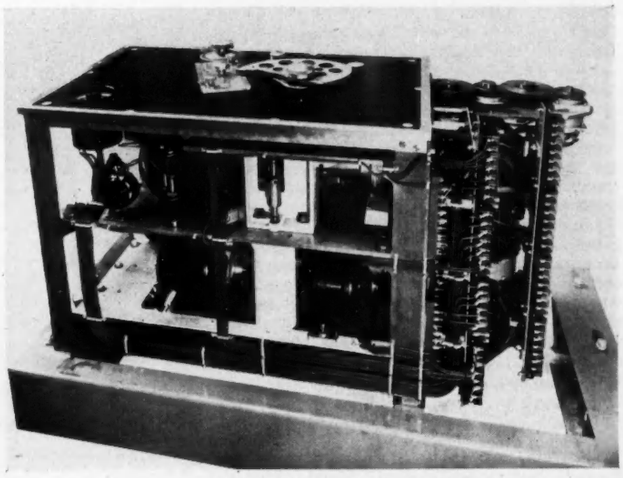

Fig. 7 The cam unit with covers removed, showing the programme cam controlling the build-up of the acceleration.

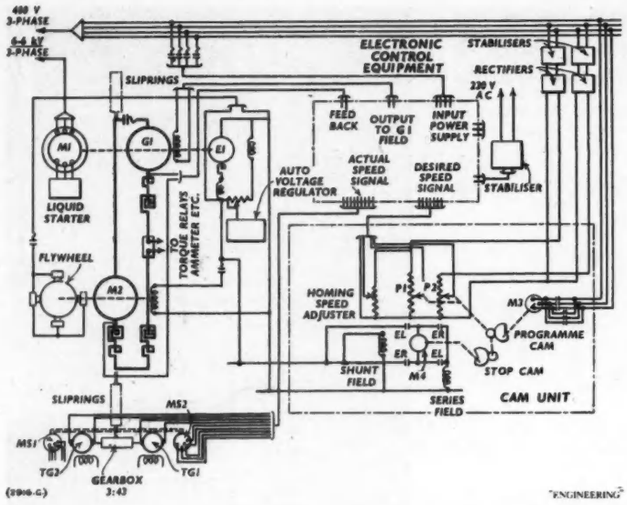

Fig. 8 Simplified diagram of the control scheme.

and similar equipments each providing communication between one arm of the centrifuge with its subject and observer, and the corresponding recording station in the medical laboratory, where the various instruments which record the physiological reactions of the subjects are situated. In addition, the controller is provided with facilities for entering each of the two circuits either to listen or speak. In normal use with human subjects aboard, the observer is in control of his Teletalk system, and if the controller or the recorder wishes to speak, he must signal his intention to the observer, who will switch the appropriate microphone into circuit. To conserve the available sliprings for their primary electro-medical purpose, and to obviate difficulties due to the effects of centripetal forces on normal telephone relays, a signalling circuit embodying magnetic amplifiers has been employed.

THE CONTROL SCHEME

A simplified diagram of the control scheme is shown in Fig. 8. The armature of the centrifuge motor M2 is energised by generator G1 of the main motor-generator set, and the field of M2 by the constant-voltage exciter E1. Variation of the speed of the centrifuge motor M2 is achieved by adjusting the excitation of generator G1, and hence the voltage applied to the armature of M2. This adjustment is made automatically by the electronic equipment in the following manner.

Two separate signals are fed to the input stage of the electronic equipment. The first of these is derived from tacho-generators TG1 and TG2, which are geared to motor M2 and thus develop a voltage proportional to the instantaneous speed of the arm. Two tacho-generators are employed as a safety precaution; a differential relay connected across them initiates a shut-down in the event of any inequality between the two systems. The second signal is derived from the cam unit, and is proportional to the desired instantaneous speed. The difference between the signals represents the instantaneous speed error, and constitutes the actuating signal to the input unit of the electronic equipment. From this unit the error signal is passed to a two-stage valve amplifier which incorporates a stabilising network for the control system, and hence to the control grids of a three-phase thyratron rectifier which constitutes the output unit and is used to energise the field of G1. The error signal thus varies the excitation of G1 in the appropriate sense to correct the discrepancy in motor speed which initiated the signal.

CAM UNIT CONTROLS RATE OF ACCELERATION

The cam unit (Fig. 7) which provides the desired instantaneous-speed signal, consists primarily of a pair of potentiometers, P1 and P2 (Fig. 8), which are traversed by brushes attached to an arm. Movement of this arm is controlled by a programme cam or a stop cam in the manner described below. As in the case of the tacho-generator, two potentiometers are employed to ensure safety, and any discrepancy between the two systems will cause operation of a relay which initiates a shut-down. The potentiometers are bow-shaped and are mounted one above the other; the effective radius of the brush arm is 24 in. and the total travel between the low and high-speed position 41½ deg. The reference voltage provided from the potentiometers varies from zero at standstill to 400 volts in the high-speed position. The signal fed to the electronic equipment is the difference between this and the voltage developed by the tacho-generators, and a difference of less than one volt will result in full excitation of the generator. The arm is moved towards the high-speed position by a weight to which it is attached by means of a chain passing over a pulley. The arm bears against the programme cam, which, when rotated, permits the arm to move at a rate dependent upon the profile of the cam. This cam is rotated by an induction motor through a V-belt drive equipped with multi-step pulleys which enable the appropriate cam speed to be pre-selected. The test cycle of the centrifuge is controlled by the profile of the programme cam, and a range of cams covering the various test requirements is provided.

The stop cam follows the travel of the arm in such a manner that it can take over the duty of pushing the arm towards the low-speed position with the minimum of delay. The stop cam cannot be changed, and the speed at which it can move the arm to the lower speed position is fixed by safety considerations. It is brought into action only on failure of the programme cam, on remote stopping, or when the overall time limit has expired. The stop cam is driven by the direct-current motor M4. The cam unit includes a series of interlocks to ensure the correct orientation of the cams, and their return to the low-speed position for starting. The cam unit is also provided with a series of "*g* plates," one of which must be inserted before the apparatus can be used. Each plate acts as a definite stop to the travel of the brush arm, and thus limits the maximum speed of the centrifuge to a predetermined value. Plates with stops at 10*g*, 15*g*, 20*g* and 30*g*, are available.

PROGRAMME CONTROL

The control equipment provides facilities for two automatic systems and one manual system of programme control. The automatic system provides a complete programme of acceleration and retardation from start to stop. The controller may take over control of the arm by operating the manual/auto switch, but if this is done it is not possible to return to automatic control. The automatic control provides for long runs under programme control, without subjects present in the cars, for duration tests.

Under manual control, control columns of the controller and the subject operate twin-torque transmitters through quadrants, and associated twin-torque receivers impart an equivalent movement to a follow-up drum controller Although each control column can be moved independently, the drum controller is so arranged that all three operators must agree to raise speed, but any operator can lower speed in contradiction to the others. If a subject is absent, the relevant switch is closed to short out the interlock circuit; otherwise both the subjects' dead man's handles must be retained throughout the run. If either handle is released, the controller is warned by an indicator lamp, and he can then take over by cancelling the appropriate handle release. If he fails to take over within 5 seconds the stopping sequence is initiated. Once operated, the take-over circuit cannot be re-set until the end of the run. It is a feature of the system that even under manual control, either by the subjects or the controller, the action is always effected through the cam unit. The rates of acceleration and of retardation of the whirling arm and its top speed are therefore limited by the shape of the cam in position, no matter how fierce the operators may be in their handling of the control columns.

To bring the centrifuge arm to rest in the correct orientation at the end of each test, the operation of the control unit is automatically changed from that of a speed controller to that of a position controller. This change takes place as soon as the speed of the arm has fallen below a specified value, and the speed of approach of the arm to the home position is then reduced in proportion to its distance from the home position. To achieve this one of the Magslip transmitters geared to the centrifuge arm (the other is a standby) co-operates with each of the two Magslip coincidence transmitters located in the electronic cubicle. As the speed of the arm

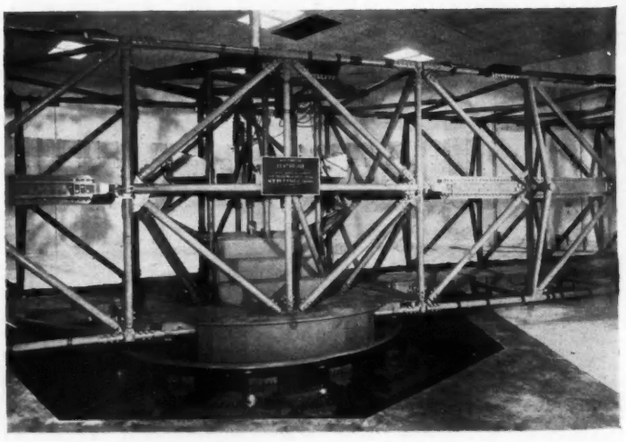

Fig. 9 Centre section, showing part of the cast-steel ring with the friction brakes and emergency rollers which cater for out-of-balance loads on the arm.

falls to the given value, a relay operates and causes the reference voltage derived from the cam-driven potentiometer to be replaced by a fixed voltage, so that the arm moves on at a fixed speed. When it reaches a position 60 deg. in advance of home, the first coincidence transmitter actuates a relay which transfers the control from the fixed voltage to the voltage produced by the second coincidence transmitter, and this is proportional to the displacement of the arm from its final position. The speed therefore diminishes uniformly as the arm proceeds to the home position. Just as it reaches there the second coincidence transmitter actuates a relay which opens the generator excitation circuit, closes suicide windings on both generator and motor, and allows the mechanical brakes to operate.

The centrifuge can be moved into position under "inching" control from pushbuttons on the control desk; under these conditions the field of generator G1 (Fig. 8) is connected to the constant voltage exciter E1, and the electronic equipment is not used.

BRAKING

The stop buttons and various trips in the stop circuit normally initiate an electrically-controlled retardation of the centrifuge. In the event of a failure of the electronic equipment, operation of an emergency stop button, or the failure of the power supply, the supply to the motor is tripped, and the arm slows down under the action of the mechanical brake, coming to rest without operation of the homing sequence. The control circuit is arranged to ensure that mechanical and electrical braking can never take place simultaneously.

The mechanical braking is hydraulic in action, and is controlled by means of valves actuated by direct-current solenoids. Under normal stopping conditions the brakes remain in-operative until the arm is virtually "home," when they are applied and used also as "holding" brakes.

The brakes comprise eight spring-loaded fabric-lined shoes equally spaced on the periphery of the cast-steel ring to which the rotating arm is secured at its centre. A hydraulic cylinder operates on each brake shoe, alternate cylinders being supplied from separate hydraulic pressure circuits. The hydraulic pressure units, supplied by Automotive Products Company, Limited, Leamington, are located in cabinets in the wall of the motor pit. Each unit comprises a piston-type accumulator, using nitrogen, capable of storing sufficient fluid to make four emergency stops should the pump-motor supply be interrupted. Each accumulator is charged from a radial pump directly coupled to a 1-h.p. motor. When the pressure in the accumulator rises to 1,250 lb. per square inch, a by-pass valve returns the pump discharge to the storage tank (atmospheric pressure); charging commences when the accumulator pressure falls to 950 lb. per square inch. Contacts in the main control circuit ensure that the rotating arm cannot be started in the unlikely event of hydraulic pressure not being available. These contacts are closed by the accumulator pressure (as required for the above four applications of brakes).

The supply to the brake cylinders is through a deadweight loaded control valve, the pressure in the cylinders being determined by the pressure exerted at the valve through the deadweight. To relieve cylinder pressure the deadweight is raised through a solenoid acting on the deadweight arm, the pistons and brake shoes being retracted by direct-acting springs.

During all operational runs, after the regenerative braking has decelerated the arm to a low speed, the friction brakes are applied to complete the final stage of stopping, and for holding between runs.

To minimise any damage which might arise from excessive out-of-balance in the loading of the rotating arm, steel rollers are fitted. They are carried in independent cast-steel brackets, each adjustable in a horizontal plane by wedges, to permit adjustment to the fine clearance required between the roller faces and the cast-steel ring. The rollers and the brakes can be seen in Fig. 9, which shows the centre section of the rotating arm and part of the cast steel ring which carries it.

TORQUE LIMITATION AND OVERSPEED PROTECTION

Although the maximum speed and rate of change of speed are governed at all times by the profile of the cam in use, the control scheme incorporates a number of additional safety features to protect the ultimate mechanical safety of the centrifuge; they do not form part of the normal control circuit.

The maximum motor torque is limited by the action of two torque-limit relays which are energised from a shunt in the armature circuit of M2. The first relay is set to operate at 101 per cent. of the permissible armature current, and will arrest further acceleration until normal conditions are restored. An adjustable timing relay is started by the first torque-limit relay, and this will initiate the stop sequence if the over-torque condition is sustained beyond the set time. The second torque-limit relay is set at 110 per cent., and, on operating, will immediately initiate the stop sequence.

Three overspeed devices are fitted to the centrifuge motor and are mechanically driven from the high-speed shaft of the gearbox. Two are set to operate at 5 per cent. overspeed under normal conditions, and the third operates when the reduced maximum speed permitted when using heavy cars is exceeded by 5 per cent. Operation of any of these mechanisms immediately initiates the stop sequence.

The period for which the centrifuge runs at top speed when under programme control is determined by a programme timer. An overall-time controller, which operates irrespective of the control system in use, is fitted; it consists of two timers covering ranges of 0 to 100 seconds and 0 to 100 minutes, the appropriate range being selected by means of a changeover switch. On commencing a run the selected overall timer starts as soon as the raise-speed contactor is closed, and after the set time interval the stop cam is brought into action, unless, in the meantime, the programme timer has operated or the centrifuge has been brought to rest manually.

When the programme timer has operated and given a signal to lower the speed, the operating coil of a delayed-action checking relay is energised. Under normal conditions the control potentiometer starts to move towards the lower speed position, and thus trips a switch which opens the operating coil circuit of the relay before the contacts close. If, however, the potentiometer has not started to move before the relay contacts close, the stop cam is set in motion.

To guard against a transmission failure in the gearbox, with consequent loss of control due to the absence of a signal from the tacho-generators, a voltage relay is set to operate as soon as the main generator attains a voltage slightly above that corresponding to homing speed. A further relay, operated by the tacho-generator and set at the homing speed value, opens the coil circuit of the first relay when conditions are normal, but if the tacho-generator voltage fails the first relay will close as soon as the homing speed is exceeded, and will initiate the stop sequence.

A voltage relay across the output of the main generator is set to operate at a voltage slightly above that required for homing the centrifuge. A normally-closed contact on this relay opens the suicide contactor circuit at all voltages above this value, and prevents suiciding at high speed in the event of failure in the homing circuit. A normally-open contact on the same relay prevents the homing speed reference being given to the electronic equipment at all generator voltages above that required for homing.

An interlock circuit is provided to prevent the centrifuge from being started until the car doors have been locked and the doors leading into the centrifuge chamber have been closed. The chamber doors cannot be re-opened until the whirling arm has again come to rest.

COMPRESSOR PLANT FOR BELGIAN AIRCRAFT FACTORY

A three-stage air compressor plant has been supplied recently by Williams and James (Engineers), Limited, Chequers Bridge, Gloucester, to Société Anonyme Belge de Constructions Aéronautiques (SABCA) for installation in one of their plants at Haren, near Brussels. This concern is engaged in the construction of aircraft undercarriages and other hydraulically operated units and the air compressor has been installed for testing airborne hydraulic equipment. The output of the plant is 6 cub. ft. per minute (free air) at a maximum pressure of 3,500 lb. per square inch.

The plant consists of two separate compressor units mounted on base plates, a control panel and two sets of air receivers. One compressor is a two-stage double-throw single-crank water-cooled machine, the first-stage cylinder having a bore of 3 in. and the second stage a bore of $1\frac{1}{16}$ in. The stroke is 3 in. The compressor is belt-driven by a 5-brake horse-power electric motor. The other compressor unit, belt-driven by a $2\frac{1}{2}$-brake horse-power electric motor, is a single-stage water-cooled booster (third stage) having a bore of $\frac{5}{8}$ in. and a stroke of $2\frac{1}{2}$ in. The control panel includes coolers, air dryer, electrical contactors and pressure switch. One cooler operates after the first stage of compression, the other after the second stage.

The pressure-switch controls the 5-brake horse-power electric motor through an automatic contactor; the operating range of this pressure switch is 800-1,000 lb. per square inch. It is connected to the two 1,000 lb. per square inch working-pressure air receivers; it also operates a solenoid, which exhausts the air from the pipes between the first- and second-stage cylinders and from the pipes connecting the second-stage cylinder and the air receivers.

The air, after having been compressed to 1,000 lb. per square inch, enters the air receiver nearest the panel and thence through a Birlec Lectrodryer to the second air receiver, from whence it can be extracted in a very dry state at 1,000 lb. per square inch pressure.

The re-activator unit for the Lectrodryer consists of a cylinder containing an electric heater element. Compressed air (obtained from another source) at a pressure of 15 lb. per square inch, is passed through the re-activator unit where it is heated, and thence through the contents of the Lectrodryer in the opposite direction of flow to that taken by the air discharged by the second stage of compression.

It will be seen that there is a constant supply of air available at a pressure of between 800 and 1,000 lb. per square inch and that up to this pressure the plant is fully automatic. When air at 3,500 lb. per square inch is required, the booster unit is also used and air drawn from the second 1,000-lb. per square inch working-pressure air receiver, through a pressure-reducing valve where the pressure is reduced to 600 lb. per square inch. After compression in the booster, the air is fed to two high-pressure air receivers.

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KT 55 BEAM TETRODE

Two KT 55 beam tetrodes, a valve recently introduced by the General Electric Company, Limited, Magnet House, Kingsway, London, W.C.2, when used as pentodes in push-pull are capable of an output of 25 watts from a direct-current mains supply of 220 volts. The valve has proved particularly useful for modifying alternating current equipment so that it can be operated from direct current mains, or from on non-standard alternating current frequencies. It can be used as a power generator in cases where a low-power alternating-current motor is required to be driven from a direct current mains supply, as for example an alternating current 3-speed gramophone motor.

UNIVERSAL PILE DRIVER

RAKING, SLEWING, TRAVELLING AND ASSEMBLY UNDER OWN POWER

Universal pile-driving equipment with a 65-ft. frame and a 100-ft. adjustable telescopic leader was recently demonstrated on the premises of its makers, Woodfield Hoist and Associated Industries, Limited, Frindsbury Works, Rochester, Kent. The unit, which is illustrated in Fig. 1, was shown to be fully adaptable and capable of a wide range of movements and applications. The frame, for example, may be inclined to give considerable backward and forward rake, and the angle of hammer stroke can be further modified by relative adjustment of the leader; Fig. 2 shows three possible attitudes of frame and leader. The equipment is self-erecting; and raking, slewing and travelling are also effected under power by means of a steam plant, which serves in addition to raise the hammer. A single-acting hammer of 7 tons may be employed or a drop-type weighing 4 tons, and pitching piles of between 9 and 10 tons can be used.

BUILT FOR ROAD AND BRIDGE CONTRACT

The Woodfield "7/100" universal pile frame has been built to the order of Christiani and Nielsen Limited, Romney House, Tufton-street, London, S.W.1, for the Hampshire County Council Langstone Bridge contract, and the work for which the new equipment is to be used gives some indication of its capacity.

The contract includes the reconstruction of over 3,000 ft. of roadway connecting Hayling Island with the mainland. Of this about 1,600 ft. will be built on new embankments; 956 ft. will comprise the bridge over the channel; and the remainder will be the present road re-routed. The channel is to be bridged in 29 spans of 32 ft. with a number of smaller spans at expansion joints. The roadway, which is to be 22 ft. wide, will be supported on 16 precast prestressed beams, and footpaths cast *in situ* will lie between the outermost of these beams and a parapet beam. Service ducts will be sited under the footpaths.

The road beams are to span between capping beams at the piers, each of which will be formed from 5 concrete piles of 16-in. by 16-in. section. The outer piles are to be raking. It is anticipated that some of the piles will be 80 ft. long and will weigh over 9 tons, and to drive them a hammer with a falling ram of 6 tons has been thought necessary. The concrete piles will be driven from a temporary timber staging driven in advance of the main pile-driving operation by a smaller pile frame.

Such a task as this calls for a pile driver 100 ft. high, of substantial construction, and capable of slewing, raking and travelling on an undercarriage. With so large a frame it is advisable to have these operations carried out under the pile frame's own power, and to satisfy this and other conditions the 7/100 equipment was designed.

WINCH

Power is supplied by a steam plant, which operates a winch. The winch is of treble-barrel pattern and the drive to the drums is through Ferodo-lined cone-type clutches, which are hand operated by means of screw bogies. There is a separate Ferodo-lined foot brake to every drum, each of which has its own pawl and pawl plate. The drums are 16 in. in diameter and 20 in. long, and the speed of operation is 120 ft. per minute, with a safe direct working load of 5 tons. The reversing gear consists of a double eccentric link motion. Any form of hammer complying with British Standards can be used, including single-acting, double-acting, fully automatic or drop hammers.

The steam power plant employs two Spencer Hopwood boilers, a number 20 for normal service, and a number 16 for use only when piles are to be driven with a 12B hammer. There are two cylinders of 10-in. bore and 12-in. stroke, and with a steam pressure of 120 lb. per sq. in. they develop 100 brake horse-power at 200 r.p.m.

The drive to all motions other than piling or pile pitching is taken from the front drum shaft, through a claw clutch to a sprocket and thence by multi-strand chain to the main transmission shaft. On this are mounted three claw clutches, which drive through bevel gears for slewing and travelling, and through straight-tooth gears to a cross-shaft for raking; the final drive to the raking screws, however, is by bevel gear. All sprockets and clutch jaws are hardened to minimise wear, and shaft screws and axles are made from either 40-ton or 60-ton tensile steel. A feature of special interest is the low position of the crankshaft, which contributes to the quiet operation of the winch and to the reduction of vibration.

The winch frame is bolted to the upper base of the structure and may be removed with ease. Moreover, the winch, which is mounted on a skid platform is built in two halves, and the cylinders and rear drum, which comprise a single unit, can be detached from the base and used as a single-drum winch. For the two remaining drums a sub-frame can be fitted, so that a suitable Diesel or petrol engine can be bolted to the skid platform, thus providing an independent unit.

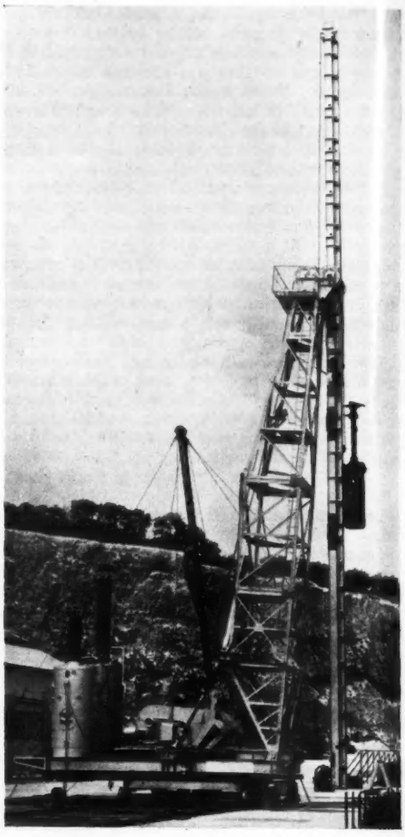

Fig. 1 The Woodfield "7/100" pile frame is capable of a wide range of piling operations and is designed to drive both vertical and raked piles. The leaders are telescopic and the height of both leaders and superstructure may be adjusted.

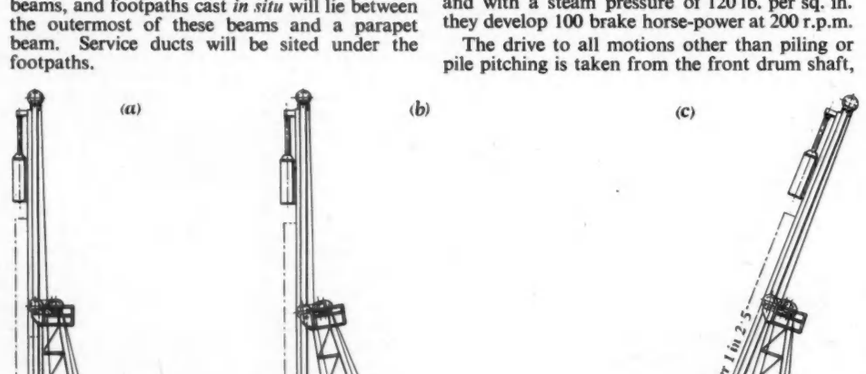

Fig. 2 The versatility of the pile frame is enhanced by use of a tilting superstructure, which is raked under power by means of two raking screws. Diagram (*a*) shows frame and leaders vertical; (*b*) frame raked forward with leaders vertical; and (*c*) frame and leaders at maximum backward rake.

BACKWARD AND FORWARD RAKING

Raking of the superstructure is performed by means of two raking screws, one on each side, and these are driven as previously explained from the main transmission shaft. The maximum backward rake is 1 in 2½, as indicated in Fig. 2 (*c*), and this is achieved by initially raking forward so that, with the locking pins removed, the first section of the leader jacking strut (fixed to the bottom of the leaders by a trunnion) slips out under the load of the free-swinging leaders. For this purpose it is extended to 4 ft. 6 in. and is then locked in place. The superstructure is then tilted back until the required rake is reached.

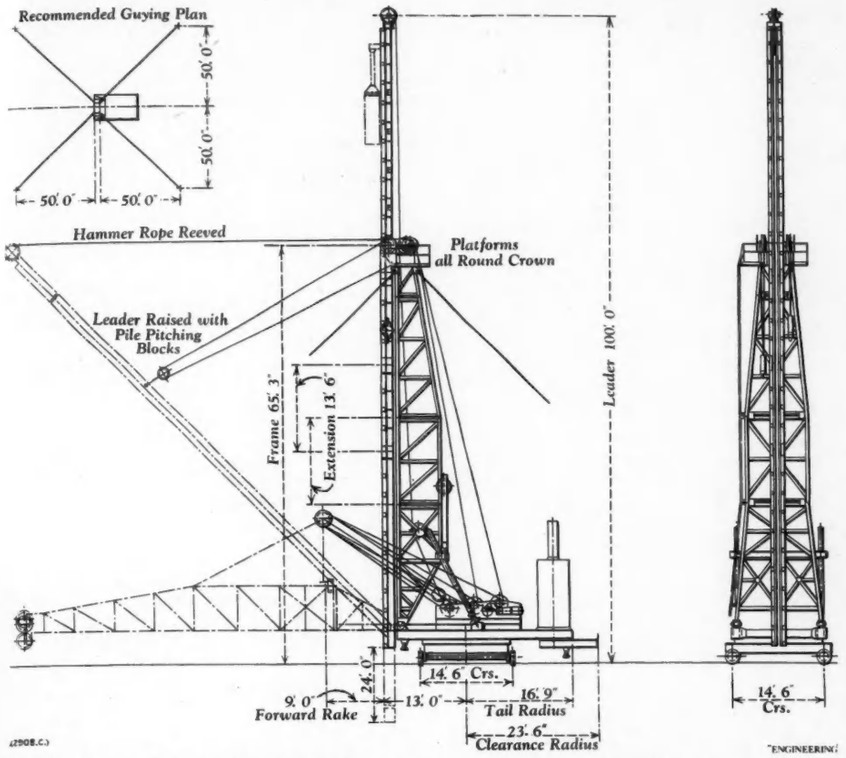

Fig. 3 Not only are slewing and travelling carried out under the equipment's own power, but also erection and dismantling of the frame and leaders.

For piling at this angle rear jacks must be employed.

Under working conditions raking is carried out with the hammer at the foot of the leaders and this applies also to forward raking. In this operation, too, the leader jacking strut is extended, but this time to its full length, as is shown in Fig. 2 (*b*). The strut is in two sections of 4 ft. 6 in., which telescope one within the other for storage. The outer section is extended as before by pendulum action of the leaders, but the extension of the inner section is effected by hand. A hand lever and ratchet give the required movement and enable a fine adjustment of strut length to be made. In the fully-extended position, the strut projects 9 ft. and the distance between the foot of the leader and the centre line of the frame is 22 ft. (Fig. 2(*b*)). The slope in the fully forward raked position is 1 in 4.

In addition to the adaptions already described the heights of both frame and leaders may be modified. As has been mentioned, the leaders are normally 100 ft. in length but they may be shortened by a total distance of 24 ft. in four steps of 6 ft. This adjustment is effected by means of four screw-pin sockets with the aid of pitching lines, and is of great value in piling from a dock side. Moreover, both the frame and the leaders can be reduced in height by removing sections from them, thus reducing the leaders to 85 ft. and the frame to 52 ft.

SLEWING AND TRAVELLING

The slewing ring, which is situated between the base and the sub-base, is made from rolled-steel channel and is jig drilled for the driving pins, which are made from a nickel-chromium-molybdenum steel, hardened and ground. The jig employed was of sine-bar type and was constructed by another division of the Woodfield Company, the Kemworthy Jig and Press Tool Company. The rate of slewing is 2 r.p.m.

For travelling the hammer is lowered to the lower leader pin or held by the drum pawl gear in the lowest position. The speed of travel is between 3 and 4 miles per hour and reversing is effected by means of a double eccentric link motion.

ERECTION AND DISMANTLING

Before the equipment is dismantled it is necessary to load ballast and drop all jacks. Two pile-pitching blocks are then shackled in place, and a line from a hand-operated light-weight hoist is fastened to the back of the leaders. The leaders are attached to the superstructure by two trunnion brackets; the lower of these embodies grooves in which the back bracing of the leaders slides, while the top trunnion, which is of unusual design, is secured to the leaders by two screw pins. To lower the leaders, therefore, they must be prevented from sliding in the bottom bracket by means of stops, and the screw pins in the upper bracket must be retracted; this is effected by two handwheels, each of which forms part of a screw head. While the pins are withdrawn, the load of the leaders is taken by the tackle already mentioned.

With the pins clear, the lift on the pile-pitching ropes is eased and the light line removed from the leaders. These are then lowered on the pile-pitching ropes from the two rear drums. Erection is performed in a similar manner but with the operations reversed, and Fig. 3 illustrates the procedure employed; the method of raising and lowering the superstructure is also indicated.

In readiness for lowering the superstructure the hammer rope is re-reeved through the sheaves on a lifting gallows which is lowered from its stowed position at the back of the frame; the rope is carried over the bridle fixed to the winch, and thence round the winch drum. The mast is next fully raked forward, with the load taken on the tackle.

The couplings on the raking screws are unbolted and as they are broken the screws are supported by means of hand tackle previously anchored to the boilers; they are thus prevented from interfering with the lowering of the superstructure. This is then brought down into a horizontal position. The use of divided raking screws dispenses with the need for mating gears on assembly.

A feature which is of special value when the equipment is to be transported by road is the method of construction which enables the complete rig to be dismantled into sections not wider than 8 ft.; the heaviest of these sections, the upper base, weighs 9½ tons. It is also of interest that most of the operations described can be carried out with the crew on the deck; this characteristic is of particular importance when the equipment is used over water.

The Woodfield 7/100 Universal pile frame is believed to be the first exclusively British unit of its kind, and the agents for this and other Woodfield piling equipment are Vales Plant Register, Limited, 14 Lower Grosvenor-place, London, S.W.1.

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LAUNCHES AND TRIAL TRIPS

M.S. "TRIASTER."—Single-screw vessel for the carriage of passengers and phosphate cargoes, built and engined by Harland and Wolff Ltd., Govan, Glasgow, for the British Phosphate Commissioners, London, S.W.1. Main dimensions: 485 ft. between perpendiculars by 67 ft. 6 in. by 42 ft. to shelter deck; deadweight capacity, about 12,000 tons. Harland-B. and W. six-cylinder single-acting two-stroke engine, arranged for burning heavy oil or Diesel oil. Launch, April 21.

M.S. "GEORGE LYRAS."—Single-screw oil tanker, built by Bartram and Sons, Ltd., Sunderland, for Marine Enterprises, Ltd. (Managers: Lyras Brothers, Ltd., London, E.C.3). Largest vessel so far constructed by these shipbuilders. Main dimensions: 557 ft. 9 in. overall by 67 ft. 9 in. by 38 ft.; deadweight capacity, 16,850 tons on a draught of 29 ft. 9½ in. N.E.M.-Doxford six-cylinder opposed-piston reversible oil engine, developing 6,800 b.h.p. at 119 r.p.m. in service, constructed by the North Eastern Marine Engineering Co. (1938), Ltd., Wallsend-on-Tyne. Service speed, 14 knots. Launch, April 22.

H.M.S. "DUNKERTON."—Twin-screw coastal minesweeper, built by the Goole Shipbuilding and Repairing Co., Ltd., Goole, for the Admiralty, London, S.W.1. Main dimensions: 152 ft. by 28 ft. 9 in. by 14 ft. 9 in.; armament, three small guns. Diesel propelling machinery supplied by Mirrlees, Bickerton and Day, Ltd., Stockport, Cheshire. Trial trip, April 23.

M.S. "GEORGINA V. EVERARD."—Single-screw cargo vessel, built by the Goole Shipbuilding and Repairing Co., Ltd., Goole, for F. T. Everard and Sons, Ltd., London, E.C.3. Main dimensions: 285 ft. by 42 ft. by 19 ft. 3 in.; deadweight capacity, 3,250 tons. Diesel engine developing 1,600 b.h.p. at 250 r.p.m., constructed by the Newbury Diesel Co., Ltd., Newbury, Berkshire. Launch, April 23.

H.M.S. "BECKFORD."—Seaward defence boat, built by William Simons & Co., Ltd., Renfrew, for the Admiralty, London, S.W.1. Length, 117 ft. 3 in. overall, with a beam of 20 ft. Armament includes small guns, depth charges and electronic equipment. Propelled by Diesel engines, vessels of this class are designed to detect and destroy submarines, including those of the midget type. Launch, April 27.

M.S. "WESTERN PRINCE."—Single-screw cargo vessel, built and engined by Harland and Wolff, Ltd., Govan, Glasgow, for the Prince Line, Ltd., London, E.C.3. First of two sister ships. Main dimensions: 435 ft. between perpendiculars by 61 ft. by 38 ft. 6 in. to shelter deck; deadweight capacity, about 10,000 ft. on a draught of 27 ft. 6 in.; gross tonnage, about 7,900. Harland-B. and W. five-cylinder single-acting two-stroke opposed-piston oil engine. Trial trip, April 27.

S.S. "PIZARRO."—Single-screw cargo vessel, with accommodation for twelve passengers, built by the Greenock Dockyard Co., Ltd., Greenock, for the Pacific Steam Navigation Co., Liverpool. Fourth vessel of this type for these owners. Main dimensions: 476 ft. between perpendiculars by 66 ft. by 40 ft. 8 in. to upper deck; gross tonnage, about 8,500; deadweight capacity, about 11,100 tons on a mean draught of 28 ft. Reaction steam turbines with double-reduction gearing, developing 9,400 s.h.p. at 108 r.p.m. in service, constructed by Parsons Marine Steam Turbine Co., Ltd., Wallsend-on-Tyne. Steam supplied by two oil-fired water-tube boilers, constructed by Babcock and Wilcox, Ltd., London, E.C.4. Propelling machinery installed by John G. Kincaid & Co., Ltd., Greenock. Speed, 16½ knots in service. Launch, May 19.

THE PHYSICAL SOCIETY'S EXHIBITION

Concluded from page 515

Among the exhibits described in the continuation of our report on the Physical Society's exhibition, are an interesting experimental loud-speaker based on corona and air-ionisation effects, a glass-working machine, and two colour-measuring instruments employing different principles. These items are indicative of the wide range of technological ideas represented at this exhibition, which thus serves as a guide to new developments. In addition to a number of longer descriptions, the report includes brief summaries of certain other exhibits.

COLOUR MEASUREMENT

Although the Lovibond Schofield "Tintometer" was first introduced as long ago as 1939, the model exhibited at the recent Physical Society exhibition on the stand of The Tintometer Limited, Waterloo-road, Salisbury, Wiltshire, is a substantially redesigned version, and its interest is to-day enhanced by its application to television. Also displayed were a set of 12 Lovibond glass cubes, which have recently received official approval for the colour grading of rosin both by the U.S. Department of Agriculture and the Indian Standards Institution; and a range of new discs for the Lovibond comparator. These comprise permanent glass colour standards for checks on hydrogen sulphide in town gas; dinitro-ortho-cresol in blood; D.D.T. on stored grain; pentachlorphenol in fabrics; cyanide, tin, zinc and nickel in water supplies; and nitrate in boiler feed-water.

The Tintometer is a colour-measuring instrument which enables colours to be matched visually, either by reflected or transmitted light, by means of the Lovibond subtractive scale of glass filters; the result is immediately transposed into the (x, y, z) chromaticity co-ordinates of the system established by the Commission Internationale de l'Eclairage. The three Lovibond primaries, red, yellow and blue, are not used together but only two at a time, and any colour may be matched by suitable combinations, provided that the relative luminance of sample and matching field can be adjusted to equality in some way. This is achieved by use of a photometric device. Applications of the Tintometer include colour measurement of liquid samples and the building-up of any colour from a C.I.E. co-ordinate specification to see what it looks like.

The Tintometer is made in black moulded plastic and contains 81 Lovibond permanent glass colour slides, covering the range 0·1 to 18·0 Lovibond units in each of the three primary colours red, yellow and blue. Each rack of nine glasses is fitted with a colourless glass so that an equal number of glass surfaces appear in each field, thus compensating for the loss of light at each surface interposed between the observer and the standard white background. The brass viewing tube incorporates a built-in C.I.E. Davis-Gibson light filter, which is a borosilicate glass cell containing two 1-cm. compartments for holding the appropriate chemical solutions.

In the new model, which is shown in Fig. 7, illumination of both sample and comparison field is provided by only one lamp by reflection from an integrating sphere, and light for the two fields is emitted from two apertures of equal area situated 90 deg. apart, one above and one below the sphere's equator. Concentric with the vertical axis of the sphere is a cylinder, round the periphery of which are cut two tapered slots, also situated so that one is above and one below the equatorial plane of the sphere. The slot centres are coincident with the sphere aperture centres, and each slot extends 260 deg. round the cylinder's circumference.

The obturating cylinder or sleeve is rotated by the operator to adjust the relative quantities of light falling on the matching fields, and a match is obtained by adjusting the glasses for hue and saturation and the photometric device for luminance. Light is supplied to either sample or matching field without backlash, and optical density is read directly from an engraved scale. Two nomograms are provided; by means of one the colour quality represented by the Lovibond glasses employed may be immediately located in its correct position on the colour diagram and its x, y, z co-ordinates obtained; and the other provides the brightness or luminance factor for the sample, either as optical density, or brightness as a percentage of the standard white.

GLASS-WORKING MACHINE

In addition to ranges of vacuum and vapour-diffusion pumps, vacuum coating equipment, and a high-speed sputtering plant which can deposit conducting metal-oxide films, W. Edwards and Company (London) Limited, Manor Royal, Crawley, Sussex, exhibited two vacuum furnaces and a general-purpose glass-working machine (Fig. 8).

One of the two furnaces has been designed to perform such operations as melting, casting and sintering under high vacuum and is of ½-lb. capacity. It is resistance-heated and has a temperature limit in excess of 2,000 deg. C. Provision is made for working in different atmospheres, and suitable controls and sight glasses are fitted to permit full supervision of the melt. The furnace is detachable from a mobile pumping unit consisting of a "Speedivac" model 403 vapour pump with a 7L4 baffle valve and a Speedivac model 1S150 rotary backing pump, with vacuum gauges and all necessary valves.

The other is an experimental laboratory arc furnace, and is suitable for the melting and coating of refractory metals and alloys at temperatures up to and above 4,000 deg. C. It may be used with both consumable and non-consumable electrodes, and employs water-cooled hearths or crucibles. Adequate pumping capacity for use of the vacuum arc in exploratory work is provided by a Speedivac model 9B3 booster pump.

The Edwards glass-working machine, which has been developed in collaboration with the British Coal Utilisation Research Association, is intended to simplify the production of articles fabricated from glass tubing. It serves to rotate two pieces of glass tubing in a flame simultaneously while work is performed on them—a process normally requiring the trained dexterity of an expert glassblower. The operation is carried out with the aid of two chucks, which firmly grip the tubing and turn it synchronously at a chosen speed, leaving the operator free to concentrate his entire attention on working the glass and on the disposition of the burners and forming tools. It is particularly useful for laboratory research and development work, but is also suitable as a production tool since it is designed for continuous operation and may be set up for repetition work by unskilled personnel.

It is capable of a wide variety of glass blowing and forming applications including sealing, flanging, pinch making, bulb blowing, tabulating, jointing, necking, conical jointing, forming graded and glass-to-metal seals, and the manufacture of such items as stopcock parts and Dewar flasks. The services required are: coal gas at 4 to 5 in. pressure water gauge, compressed air at 10 to 15 lb. per square inch, oxygen at 10 to 20 lb. per square inch, and a single-phase electric power supply of 500 watts at 200 to 250 volts and 50 cycles per second. The machine, which in form resembles a lathe, includes as standard equipment a cannon burner, a crossfire burner, a flat forming tool, a

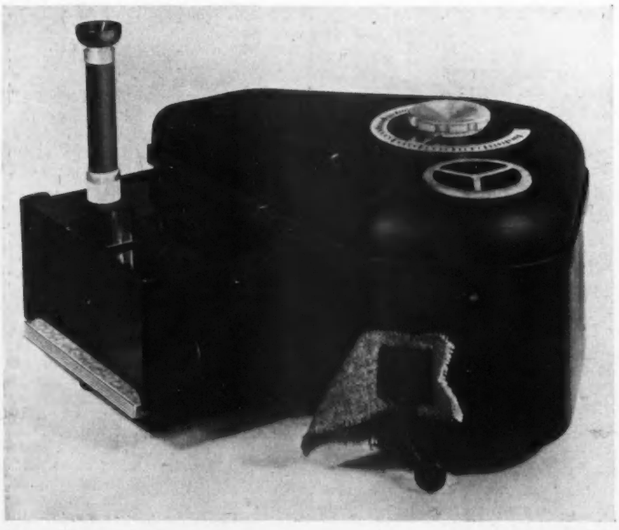

Fig. 7 The Lovibond Schofield "Tintometer" enables colours to be matched by reflected or transmitted light, using a subtractive scale of glass filters. Results are given as chromaticity co-ordinates.

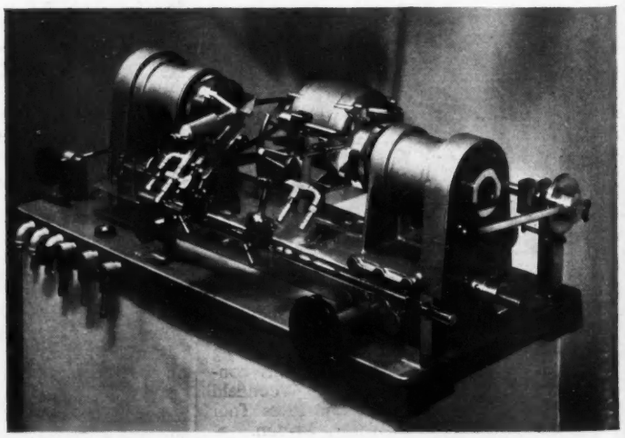

Fig. 8 With the aid of the Edwards glass-working machine, an unskilled operator can perform a wide variety of glass blowing and forming operations including flanging, jointing and flask making.

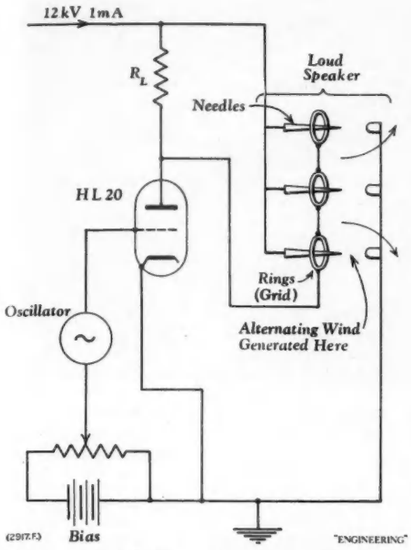

Fig. 9 Circuit diagram for a corona-wind loud-speaker having no moving parts. A small voltage on the ring grids controls the corona currents from the needle electrodes, thus regulating an associated flow of ionised air and generating an acoustic wave front.

flanging tool and a blowing fixture. Burners may be fitted for use with other gases and the machine may be adapted for any electrical supply.

CORONA TRIODE AND WIND LOUD-SPEAKER

One of the most interesting exhibits was provided by Mr. D. M. Tombs, M.Sc. (Eng.), A.C.G.I., A.M.I.E.E., Electrical Engineering Department, Imperial College, London, S.W.7, who displayed three pieces of apparatus which had emerged during studies in the field of micro-amp-kilovolt engineering. The three items shown were a corona triode, a corona-wind loud-speaker, and a linear electrostatic loud-speaker; and although still in an early stage of development, each offered considerable scope for practical application—particularly since suitable kilovolt sources were now available.

If a needle and a blunt electrode have a sufficient potential established between them, the field in the region of the needle will break down the insulating properties of the air. The air then becomes ionised and a so-called corona current (of some tens of microamps) flows between the electrodes. If a ring electrode (grid), is placed round the needle and a potential applied to it, the electric-field lines which formerly terminated on the needle and caused breakdown may now be deflected to the blunt grid where their effect is insufficient for breakdown to occur. A small voltage on the grid may thus control the corona current.

This device (a corona triode) constitutes a valve working in air (or other gas), which is suitable for use at high voltage for the control of small currents. In the region prior to sparking it shows properties like those of a vacuum triode, but with constants that are different in magnitude. With one assembly of the demountable valve shown, μ was 5, r_a was 200 MΩ and g was 25 μA/kV. The device has been employed as an amplifier with an associated anode load (which might be a pair of needles in air). It has the advantage, like the transistor, of requiring no heater supply. Stages may be cascaded and both positive and negative corona may be used.

Since the corona triode has moving air associated with the current, it follows that a speaker with no moving parts can be made, in which air is ionised and then set in motion by an electric field. Thus if a number of corona triodes are connected in a matrix to create a reasonable acoustic area, the moving air under the control of the grid may generate an acoustic wave front and become the source of sound waves. To achieve this 169 needles located at intervals of $\frac{1}{2}$ in. to form a 6-in. square were mounted together with their grids and counter electrodes on, and surrounded by, a 2-ft. baffle. The circuit for the speaker is shown in Fig. 9.

The response of this instrument proceeds smoothly up to 15 kilocycles per second and beyond, but the bass response seems to be limited more by the baffle than anything inherent in the speaker. It is coupled directly (no transformer) to a driving valve, which is not called upon to deliver power. Power is supplied at a direct potential of, say, 15 kV and 1 mA.

Apart from its use as a loud-speaker, this apparatus may be capable of certain other applications. Since the loud-speaker has a true zero frequency component (uniform breeze), it follows that the currents to the electrode will vary if air from a separate source is blown through the matrix; it may thus serve as an anemometer. Moreover, corona phenomena depend on the density and nature of the ambient gas, and the device may therefore also be useful as a pressure gauge or a gas monitor with continuous operation. Other somewhat remoter possibilities include ventilation and dust precipitation, and low-speed wind-tunnel work. Its main limitation as a loud-speaker is its non-linearity.

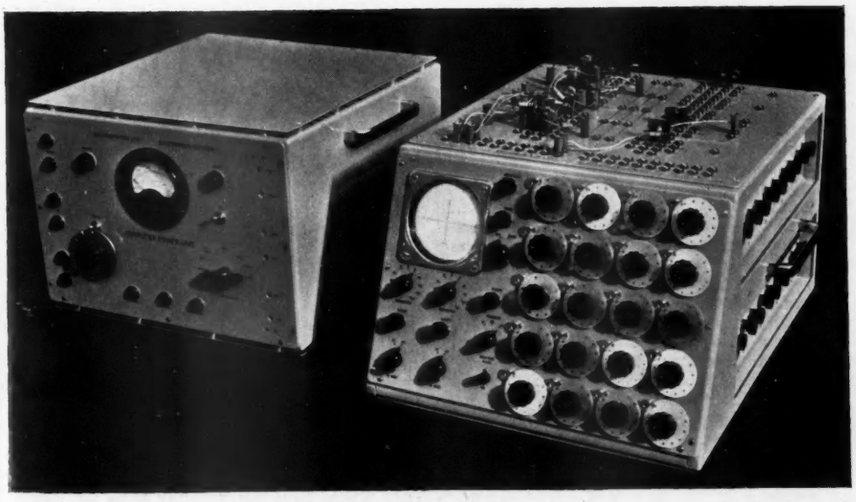

Fig. 10 The Saunders-Roe "Miniputer" is a small table-top analogue computer for solving linear simultaneous differential equations, where time is the independent variable.

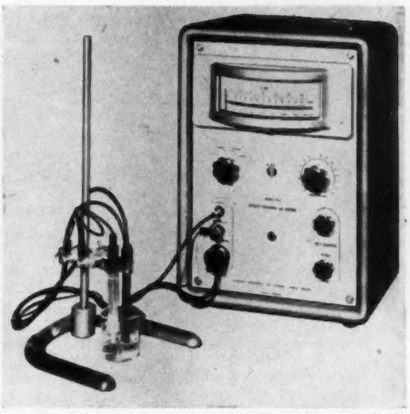

Fig. 11 Industrial *p*H meter (Electronic Instruments Ltd.). An integral electro-pneumatic converter transforms 0 to 14 *p*H inputs into 3 to 15 lb. per square inch outputs. The same company makes an automatic titrimeter for performing volumetric and coulometric titrations.

The third exhibit on Mr. Tombs' stand was a linear electrostatic loud-speaker employing three plane-parallel electrodes, the outer two consisting of open-mesh grids and the inner serving as the diaphragm. Besides being linear in response, this speaker has the advantage that, unlike moving-coil speakers, the electrostatic force producing the sound waves is applied evenly over most of the acoustic radiating area.

All the apparatus shown works with potentials up to 25 kV. Such potentials need be no more dangerous than an ordinary 230 V. supply since the current that can be drawn from high-voltage supplies can be limited by their high internal impedance. The required power of a few watts can equally well be obtained from a kilovolt source at a safe level of current, as from a heavy ampere source at a few volts, and with equal safety.

MINIATURE ANALOGUE COMPUTER

Among the items exhibited by the Electronics Division of Saunders-Roe, Limited, Osborne, East Cowes, Isle of Wight, were a variety of foil strain gauges; a computing amplifier designed for use in high-accuracy slow-speed direct-current analogue computers, or for high-speed repetitive computing; and the "Miniputer." The foil strain gauges are made from thin metal foil mounted on an ethoxylene backing. The foil may be etched into any two-dimensional pattern, and a wide range of forms were shown. The principal advantage of this method of strain-gauge manufacture is that, owing to the rectangular cross-section of the elements, very high input currents may be used with stability. It is therefore possible to drive robust meters and recording galvanometers directly, with consequent simplification of instrumentation.

The Miniputer, which is shown in Fig. 10, is a small table-top analogue computer capable of solving linear simultaneous differential equations, where time is the independent variable. It is intended for preliminary design investigations and educational purposes, and problems within its capacity include simple aerodynamic flutter and stability equations, the study of linear servo-mechanisms, and in general all linear-vibration calculations. The computer is furnished with ten operational amplifiers having a gain of 1,500 and a bandwidth of 12 kilocycles per second each incorporating a sign-reversing amplifier. The mode of operation is repetitive and solutions are displayed on a 5-in. double-beam cathode-ray tube.

AUTOMATIC TITRATION

Apparatus for performing automatically a series of titrations to a known end point, and a group of direct-reading *p*H meters were among the equipment displayed by Electronic Instru-

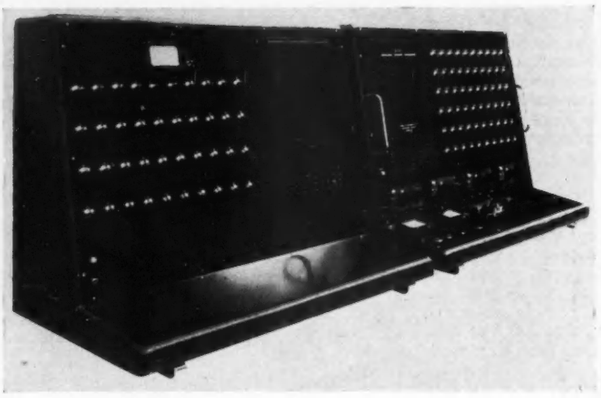

Fig. 12 Flow problems encountered in complex town-gas distribution systems may be solved by means of the Nash and Thompson gas network analyser, which employs a representative electrical network.

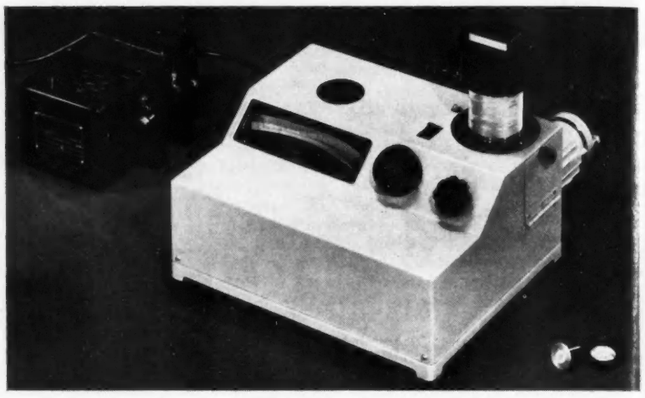

Fig. 13 By means of the Hilger and Watts "Tristimulus" colorimeter transparent or opaque samples may be inspected photoelectrically and their colours specified in terms of standard chromaticity coefficients.

ments Limited, Lower Mortlake-road, Richmond, Surrey. In addition were shown the "Chronotron" millisecond meter, which is designed to measure time intervals from 0·1 millisecond to 10 seconds in eight ranges, with an accuracy to within 1 or 2 per cent.; several megohmmeters; the "Vibron" electrometer for the measurement of small direct-current voltages derived from a high-resistance source; and a test set for electrometer-type input circuits.

The *p*H meters exhibited included a portable design for field use; an industrial meter (Fig. 11) with an integral electro-pneumatic converter, giving an output of 3 to 15 lb. per square inch for an input of 0 to 14 *p*H; and a vibrating-condenser model with high input resistance and marked zero stability.

The automatic titrimeter incorporates a control unit which is used in conjunction with standard *p*H electrodes. Two kinds of titration may be performed. For volumetric titrations a three-position solenoid-operated tap (fast-slow-off) automatically regulates the flow of the burette in accordance with the progress of the titration. For coulometric titrations a special electrolytic cell generates hydrogen ions during the course of the titration, and an integrating motor indicates the electrical usage quantitatively in coulombs. The process ceases automatically when the desired end point, previously set on the control unit, is reached.

GAS NETWORK ANALYSER

Fig. 12 shows the gas network analyser which was demonstrated at the Physical Society exhibition by Nash and Thompson Limited, Oakcroft-road, Tolworth, Surrey. This company also showed their Reid vapour-pressure recorder; a vapour-liquid ratio apparatus designed for testing liability to "vapour lock" in petroleum installations; an involute gear-tooth profile recorder based on the moving core of a differential transformer; a conductor concentricity indicator; and a series of plastic organic phosphors.

The Reid vapour-pressure recorder provides a chart record of the Reid vapour pressures of petroleum fractions. Samples can be taken from one or more points at intervals of 30 minutes and arrangements can be made for visual or audible warning to be given when predetermined limits are exceeded.

The gas network analyser is a development of the company's ventilation network calculator and is designed to assist in the solution of non-linear flow problems encountered in complex town-gas distribution systems. Problems involving flow of oil, water or other fluids to which a general law of the form $P = CQ^n$ applies may also be solved, where P is pressure, Q the rate of flow, C a constant of fluid resistance, and n is the index of flow.

The instrument makes use of a network of linear electrical resistors which can be arranged to conform in pattern to the system under investigation. This enables Kirchoff's relationships to be satisfied continuously, while the electrical resistances are successively adjusted until the electrical currents flowing in the resistors correspond to the fluid flows in the system. The resistors, which simulate branches of the system, are linked to a connection panel where the required junctions may be made, and the current and pressure drops around the network are read on calibrated meters connected into the circuit by means of jacks. Power packs stabilised against mains supply changes are provided to simulate sources of pressure, such as fans or pumps.

The model exhibited includes a separate panel incorporating a number of units which simulate loads taking constant flows regardless of the supply pressure. These may be connected into circuit in the same way as the resistors representing branches or sections of main. Little experience is required for operating the instrument and results may be obtained accurate to within $\pm$ 2 per cent.

PHOTOELECTRIC COLORIMETER

Among the numerous exhibits which appeared on the stand of Hilger and Watts Limited, 98 St. Pancras-way, London, N.W.1, was a wide range of spectrographic and spectrophotometric equipment for the analysis of metal alloys and other substances, and including a direct-reading attachment for their medium quartz spectrograph, a metal-ratio analyser, and a recording infra-red spectrophotometer. In addition were shown a recording X-ray diffractometer for performing qualitative and quantitative investigations of substances by X-ray diffraction without resource to photographic methods (this instrument was described in ENGINEERING on April 22, page 505, *ante*); an industrial galvanometer amplifier primarily for temperature measurement; hollow cathode discharge lamps for producing line spectra; linear and circular binary scales for use in conjunction with computing machines; and a photoelectric "Tristimulus" colorimeter.

The colorimeter is a simple instrument enabling colours to be measured in terms of three stimuli (or primaries). A colour under examination is viewed photoelectrically while exposed to any one of three standard forms of illuminant (known generally as the A, B and C illuminants of the internationally recognised C.I.E. system), and readings from a galvanometer allow the colour to be fully specified in terms of the C.I.E. chromaticity coefficients.

The instrument, as shown in Fig. 13, comprises a firm base on which is mounted a casing containing a sensitive mirror galvanometer and the necessary controls. On this is located a tubular unit which has an extensible lead and can be removed and used (with an additional luminator) separately from the instrument. It incorporates an illuminating system, which projects light perpendicularly upon the surface under investigation. This surface is placed on the upper end of the tubular unit, and the light diffusely reflected from it is received by a coaxial annular photoelectric cell. Alternatively, if the sample is transparent, it is inserted in the side of the instrument for measurement.

The light is filtered to give the required kind of illumination and the lamp current is regulated by a constant-voltage transformer. Readings are taken on the mirror galvanometer. A set of specially prepared light filters in a sliding mount enables measurements to be made for the three stimuli, and numerical tables simplify the conversion of readings into C.I.E. chromaticity coefficients which, together with the luminance factor also determined, specify the colour. The instrument thus determines chromaticity and reflectance or transmittance factors and may be used for opaque or transparent samples including liquids and powders.

OTHER EXHIBITS IN BRIEF

Detection of voids in plastics mouldings.—Variations in the mean dielectric constant of a moulding as it passes between two pairs of parallel plates located on either side of it are recorded, thereby indicating the occurrence of discontinuities and voids. (Chemical Inspectorate, Ministry of Supply).

Carbon gauge.—To test the quality of a carburising atmosphere a hot iron wire is exposed to it, cooled rapidly, and so transformed to Martensite. Its electrical resistance is a measure of its carbon content and hence of the carburising potential of the atmosphere. (General Electric Company, Limited).

Flaw detection with automatic scanning.—Welds, metal plate, etc., are investigated by an ultrasonic probe mounted on a gantry and linked

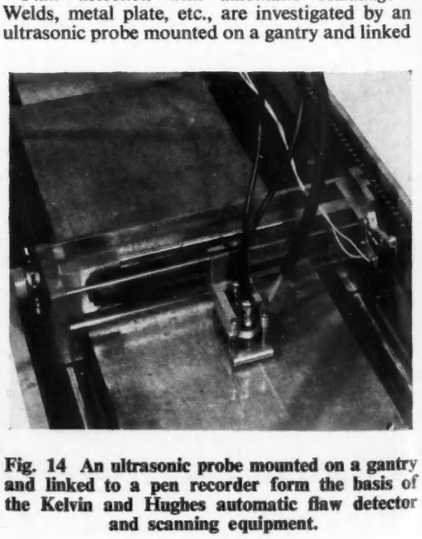

Fig. 14 An ultrasonic probe mounted on a gantry and linked to a pen recorder form the basis of the Kelvin and Hughes automatic flaw detector and scanning equipment.

to a pen recorder (Fig. 14). Areas are scanned automatically and flaws permanently recorded. (Kelvin and Hughes, Limited).

Sonic and infra-red gas analysers.—Binary mixtures of known gases may be analysed quantitatively by determination of the velocity at which they transmit sound. A practical instrument based on this principle has been constructed, which is rapid in response, inherently stable even in the presence of mild corrosion and robust in construction. (Industrial Group, United Kingdom Atomic Energy Authority.) To identify the components of a complex gas mixture separated by chromatographic methods it is possible to use infra-red analysis. An instrument employing this principle has been made, capable of estimating roughly 0·005 per cent. of ethylene in a 10 ml. sample of mixed hydrocarbon gases. (Sir Howard Grubb, Parsons and Company.)

Transducer crane weigher.—Crane loads can be measured by means of electronic weighing equipment designed to be incorporated in the bottom block of a crane hook. A tensile-load transducer, making use of strain-gauge elements, is employed and models with load ranges up to 25 tons and accuracies within ± 1 per cent. can be made. (J. Langham Thompson, Limited.)

Stroboscopic balancing machine.—Two independent cradles, each of which energises its own transducers, form the basis of the "Strobodynamic" balancing machine. The signal from the transducers is arranged to flash a stroboscopic lamp illuminating the body under test, which thus appears stationary. A pointer indicates the virtual position of the unbalance, and a meter its extent. Both bench and console models are made and workpieces from 4 oz. to 150 lb. in weight and up to 24 in. in diameter may be accommodated. The sensitivity is such that a 0·000025-in. displacement of the cradles may be measured. (E.M.I. Engineering Developments, Limited.)

Particle analysis and photo-elasticity.—The counting and sizing of microscopic samples is performed by an apparatus in which a 35 mm. film record of the particle sample is scanned by an electronic flying-spot system. Known as the Mullard "Film Scanning Particle Analyser," the instrument employs a photomultiplier tube and a magnetostrictive delay-line "memory," and a mechanism prevents the double-counting of particles intercepted in successive scans. Another Mullard exhibit is a device (employing monochromatic light, two Polaroid screens and an ultrasonic transducer) which makes visible strains set up in transparent plastic test specimens by ultrasonic waves. (Mullard Limited.)

Soils and Concrete.—Instruments exhibited for the investigation of soils included: a field tensiometer for measuring the pressure of water present in the soil; a continuous method of studying the suction induced in soil water by surface tension and adsorption forces; and an apparatus for examining the effect of load on the pressure of soil moisture. (Road Research Laboratory, Department of Scientific and Industrial Research). Also shown were instruments for measuring the thermal resistivity of soil (H. Tinsley and Company, Limited and Everett, Edgcumbe and Company, Limited) and an ultrasonic concrete tester (A. E. Cawkell).

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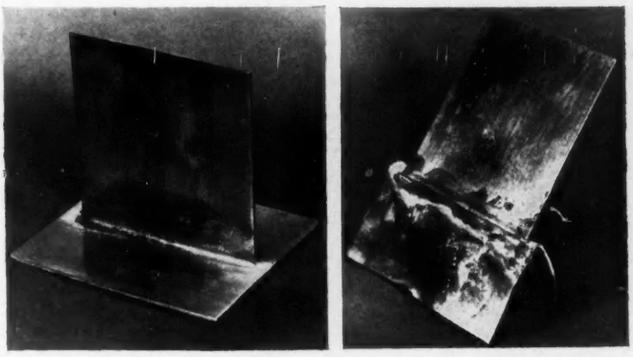
FUME REMOVAL EQUIPMENT IN P.V.C.

For handling sulphur fumes, where the degree of corrosion is excessive, a fume removal plant has been constructed entirely in rigid polyvinyl chloride (P.V.C.) by Turner and Brown Limited, Davenport Works, Davenport-street, Bolton. The equipment comprises two "Turbro" P.V.C. centrifugal fans operating in parallel, each fan displacing 5,000 cub. ft. per minute against a head of 5-in. watergauge. The fans are driven by two 12½-brake horse-power electric motors. The special "dampered" suction and discharge ducting are also constructed from rigid P.V.C.



On the left is seen a Thesscal "A" soldered joint between Duralumin and aluminium sheet $\frac{1}{8}$ in. thick. The neat joint line will be noticed. On the right is shown the same joint after being hammered; the aluminium parent metal has been cracked, but the joint is not affected.

THE HARD SOLDERING OF ALUMINIUM

Corrosion-Resistant Joints

Research conducted in the laboratories of the Sheffield Smelting Company Limited, Royds Mill-street, Sheffield 4, for the purpose of devising a method of making corrosion-resistant soldered joints in aluminium and aluminium alloys, has led to the development of the "Thesscal" process, which, it is stated, fills the gap between soft soldering performed at 250 deg. C., or less, and brazing, which requires temperatures of the order of 600 deg. C.

Two solders, in particular, have proved most useful in industrial use, for joining aluminium and aluminium alloys, not only to one another but also to dissimilar metals, such as copper and its alloys, nickel and its alloys, and steel, including stainless steel. These solders, Thesscal "A" and "P.12," have been approved by the Ministry of Supply to specifications DTD 900/4367 and 900/4398, respectively, after extensive corrosion tests at the Royal Aircraft Establishment, Farnborough. Both are described as "hard" solders and the "A" material has a melting range of from 420 deg. to 450 deg. C. Its main application is on sheet metal and fabricated forms of aluminium and its alloys. This, it is pointed out, is a free-running solder, and the technique of joining is very similar to silver soldering. A Duralumin to aluminium joint made with the "A" solder on $\frac{1}{8}$-in. thick material is shown in the accompanying illustration. It may be noted that after being hammered, the aluminium parent metal has cracked, but the joint line is not affected. The "P.12" solder has a longer melting range, namely, from 440 deg. C. to 510 deg. C. It is not so free running as the "A" solder and can be moulded much like plumber's solder. It is intended principally for use with aluminium casting alloys, to repair broken castings, build up lugs and protrusions, join castings to sheet-metal, and fill in holes.

Both the "A" and the "P.12" solders are used with "Flux 92," a powder which melts at about 400 deg. C., and the technique of the soldering operation involves heating with a hand torch using any combination of gases, such as air-coal gas, oxy-coal gas, oxy-hydrogen and oxy-acetylene. A rod or strip of the solder is warmed and dipped into the flux when this adheres to the rod in the normal manner. The work is then heated by the torch and the flux applied on the end of the solder to the joint area where the flame is not playing directly on it. When the flux melts and flows freely, the temperature is about 400 deg. C. The heating is continued until the solder melts and flows and the work can be completed in the usual way.

Two considerations have to be taken into account when employing the process. The first is that the flux is corrosive and must be washed off the joint. It is pointed out, however, that the flux has the advantage of being very soluble in hot water and this facilitates its removal. The second consideration is that Thesscal soldered joints cannot be anodised because they are attacked chemically by the anodising solution. This difficulty can be overcome by using a proprietary stop-off lacquer prior to anodising. Where some form of protection of the whole assembly is called for by specification, etching primers and paints can be employed.

Joints made by the new process, we are informed, have been tested for corrosion resistance by the Aluminium Development Association, the Ministry of Supply, and several prominent engineering firms as well as by the Royal Aircraft Establishment. For example, joints between aluminium and Duralumin members have been tested by immersion for 100 hours in tap water at 100 deg. C., and for 1,000 hours in cold 3 per cent. salt solution. Salt-spray tests, and humidity tests lasting 9 months, were also made and the joints passed all tests satisfactorily. In addition, sets of soldered joints have been exposed, in the open, to the industrial atmosphere of Sheffield for more than two years and the joints were found to be still mechanically sound.

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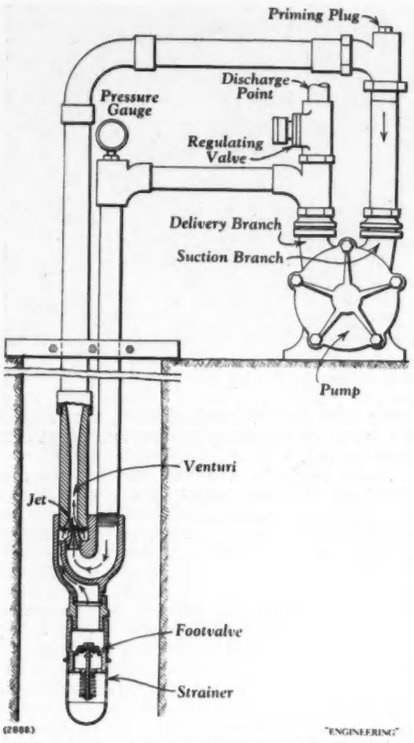
MEASUREMENTS IN RESTRICTED SPACES

Oil-Well Bore Caliper

An instrument which can be passed through 2-in. diameter tubing and then measure four radii of up to 18 in. 90 deg. apart with an accuracy of $\pm \frac{1}{4}$ in. has been developed by the United States Bureau of Mines.* The caliper probe is 1¾ in. in diameter and 6 ft. long. The electrical control and measuring circuits are encased in a stainless-steel tubular case. The essential parts of the instrument are: the calipering arms and means to expand them against the walls of the borehole and retract them when desired; means of signalling to the surface the position of the arms, and of switching the measuring circuit from one arm to another; an armoured electrical cable to the surface, and surface equipment to control the probe, record the signal, and measure the depth.

The measuring arms are held in to the body of the probe until the measuring position is reached. The arms are then raised from a vertically downwards to a horizontal position by hydraulic pressure, the pressure being produced by a piston moved by an electric motor. The hydraulic pressure is communicated to four plungers which activate the four measuring arms, and allows each arm to force itself against the side of the borehole and then come to rest. The position of each arm is registered by a variable resistance connected to the plunger, and readings are recorded at the surface which indicate the position of each arm. There is only one measuring circuit connected to the surface, and it is therefore necessary for the position of each arm to be measured in turn, which is done by a switching device. The motor can be run in the reverse direction causing the hydraulic pressure to be withdrawn from the plungers, and the measuring arms assume their positions in the body of the probe under the influence of springs.

* "Bureau of Mines Well-Bore Caliper," Report of Investigations 5092, obtainable from Bureau of Mines, Publications Distribution Section, 4,800 Forbes-street, Pittsburgh 13, Pa., U.S.A.



The " Hydro-ejector " attachment for increasing the suction lift of pumps can be used in boreholes down to 4 in. in diameter. In conjunction with a normal centrifugal pump, water can be raised from a depth of 170 ft. below the pump.

INCREASING SUCTION LIFT OF PUMPS

" Hydro-Ejector " Attachment

An attachment for increasing the suction lift of pumps has been developed by James Beresford and Son, Limited, Stork Works, Kitts Green, Birmingham, 33. It is claimed that the pump can be placed 170 ft. above the water level, and still deliver about one-third of normal discharge.

The layout of the system and details of the " Hydro-ejector " are shown in the accompanying illustration. The Hydro-ejector assembly, which is suspended on the pipe-work and submerged in the well or borehole, comprises a converter-bowl fitted with a jet, a venturi tube and a footvalve and strainer. The minimum borehole diameter in which this attachment can be used is 4 in. A regulating valve is fitted between the pump outlet and the point of discharge, as shown in the illustration. This valve has to be adjusted to direct a part of the pump discharge down the pressure pipe and through the jet in the Hydro-ejector unit. The water issues from the jet at high velocity and is directed into the venturi tube. As it enters this tube it takes with it a quantity of well-water which is forced up the pipework to a point which comes within the normal suction range of the pump (about 20 ft.). At this point the pump takes over and delivers the water the rest of the way. There is a minimum discharge pressure below which the pump pressure must not drop as otherwise it would lose its prime. The regulating valve must be adjusted to control this, and the pressure is indicated on the pressure gauge.

The Hydro-ejector may be employed in conjunction with an electrically-driven or petrol-driven Beresford pump, and electrical sets may be arranged for automatic operation. Performance of the Hydro-ejector when used with the electrically-driven Beresford B.49 pump is shown in the table.

Discharge head above pump (ft.)	Depth from pump to water level (ft.)		
	80	120	170
	Output per hour, Imperial gals.		
10	260	205	90
100	260	205	90
130	250	145	—
170	145	—	—

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TELEVISION RECORDING EQUIPMENT FOR VENEZUELA

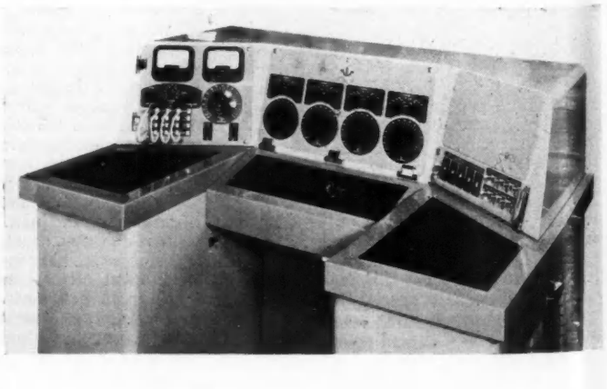
Electric and Musical Industries, Limited, Hayes, Middlesex, have recently designed and built a console control desk and transportable four-channel mixer for Compania Shell de Venezuela, a company which provides film and film material for two television programmes in that country. The equipment will be used to handle material from various programme sources and feed it to a film recording unit as well as to a number of tape and disc recorders.

The new console, which is illustrated below, provides four microphones and eight line inputs. Each microphone circuit has its own pre-amplifier to bring the input up to zero reference level. Of the eight line inputs seven are 600 ohm, balanced at zero reference level, and one is a high impedance input for connection to a radio feeder unit. The inputs are selected and connected to four equaliser units through a plug-and-jack panel and individual attenuators.

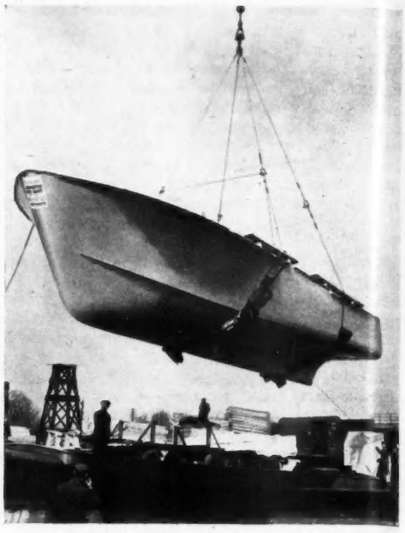
Each equaliser unit gives a bass cut of 3, 6 and 9 decibels per octave below 250 cycles, and a six-way top control gives five steps of sharp cut-off at better than 12 decibels per octave at 5, 7, 8, 11 and 18 kilocycles, as well as flat response at the sixth position. The outputs of these equalisers are mixed and fed through a master attenuator to a twin line amplifier, the outputs of which can in turn be fed to any two of four lines. There are two programme level meters, one of which is permanently connected to the output line, while the other can be switched to the input of any of the four channels. Monitoring facilities are provided by a separate monitoring amplifier, which can be switched to any of the four channels or to the main output line.

In addition, the console provides facilities for the remote control of two tape recorders in the studio, and for intercommunication with the studio through a separate amplifier and loud-speaker. The use of this intercommunication system when the studio microphone is alive, or the use of the control room monitor speaker when the intercommunication system is alive, is prevented by electrical interlocks.

The four-channel mixer consists of three microphone inputs with individual pre-amplifiers and attenuators, and a 250-ohm input for use with a film camera. After mixing, the signal is passed through a master fader to a line amplifier with a 600-ohm balanced output at zero reference level. This amplifier has three stages of bass equalisation giving 3, 6 and 9 decibels per octave below 250 cycles.



Console desk for control of the recording of television programmes in Venezuela.



All the main features of this hull were moulded in a single piece.

GLASS FIBRE HULL

Elaborate Moulding for a 54-ft. Motor-Cruiser

Last year Halmatic Limited, Rodney-road, Portsmouth, constructed the 45-ft. motor cruiser Perpetua which was then the largest plastics hull that had been made (ENGINEERING, vol. 178, page 252, 1954.) Now they have produced in a single moulding a 54-ft. hull for a sea-going motor-cruiser. The hull, which is shown in the illustration above, weighs 6,000 lb. and was sent to Teddington for fitting out.

The material used is Deborine, the name given by Halmatic Limited to a plastics material, based on the polyester resin Christic 189, reinforced with glass fibre. The skin thickness is approximately $\frac{3}{8}$ in. and is reinforced with $1\frac{1}{2}$-in. deep hollow " top hat " frames at 12 in. intervals. A pearl grey colouring material was worked into the outer surface. Moulding possibilities have been utilised in moulding-in a spray chine which also serves to strengthen the structure. Recesses were made in the moulding to take a stainless steel stern shoe and two A-bracket pads. The keel or skeg has also been moulded into the hull, the skin being increased to $\frac{3}{4}$ in. along the base. Beneath the skeg, a replaceable 3-in. greenheart chafing piece has been fitted, and the skeg itself is strengthened by transverse Deborine diaphragms which are flanged to form part of the frames. Aluminium engine-bearers will be through-bolted to the skin, the heads of the stainless-steel bolts being countersunk. A model of the hull was tank-tested, and the hull itself was built under Lloyd's survey. The craft will be fitted with two 200-h.p. Rolls-Royce engines, giving a speed of about 20 knots.

AUTOMATIC CONTINUOUS OIL-BLENDING PLANT

INSTALLATION AT MANCHESTER OIL REFINERY

With the object of blending lubricating oil more economically, and at the same time improving its quality, Manchester Oil Refinery Limited last year put into operation at their Barton refinery the first fully-automatic continuous blending unit in Great Britain. This plant, manufactured by the Cornell Machine Company, 99 Wall-street, New York, U.S.A., is capable of blending lubricating oil from up to six components at one time, at a maximum output of 90 gallons per minute.

The unit consists of two sections—a proportioning panel for controlling the ratio of the components, shown in Fig. 1, below, and a homogeniser, shown in Figs. 2 and 3, where blending is completed. The operation of these two sections is controlled and synchronised electrically.

The oils to be blended are drawn from storage by proportioning pumps of the rotary positive-displacement type, individually calibrated. They are then fed in a constant predetermined ratio to the homogeniser and thence under pump pressure to storage tanks for filling drums or bulk dispatch.

Each ingredient of the blend is measured by the proportioning panel to an accuracy of within 0·1 per cent. of the required volume of that ingredient. The accuracy of proportioning is affected by three factors—the accuracy of volume adjustment (including temperature compensation), pressure control, and air elimination.

VARIABLE-STROKE PROPORTIONING PUMPS

Micrometer adjustments allow the length of stroke of each proportioning pump to be controlled within fine limits. This takes care of the first factor—accuracy of volume adjustment. Since there are over 1,800 divisions between the lowest and highest calibrated flow positions on the oil pumps, the volume of each oil constituent can be pre-determined within about 0·05 per cent. without interpolation between divisions.

Two speed ranges are incorporated on the smaller additive-proportioning pumps. The low speed range is used for percentages between 0·1 and 3·5 per cent. of the total blend volume. The high speed range is used for percentages from 1 to 14 per cent. For stroke positioning there are over 700 clearly marked division points between the upper and lower calibrated flow rates. On the low speed range, this enables the volume of each additive to be set to within 0·005 per cent. without interpolation between the divisions, and on the high speed range to 0·02 per cent. without interpolation.

Calibration charts have to be drawn up for conversion of blend-formulae percentages to micrometer volume-control readings. These are based on the volume of oil at 60 deg. F., a temperature correction chart being used to reset the various controllers to compensate for the actual temperature of each ingredient being proportioned. Dial-type thermometers are used to record the temperature of each oil and additive.

PUMPS AS ENERGISED METERS

To control the pressure, each proportioning pump is arranged to discharge into a common manifold and is supplied by a particular pressure-controlled booster pump. Speed synchronisation is achieved by driving all the proportioning pumps with a single motor.

By means of a back-pressure regulator, the discharge pressure of each pump is maintained at a constant gauge pressure. The suction pressure of each proportioning pump is held constant at the same pressure through other control mechanisms working on the discharge pressure of the individual booster pumps which supply each main pump. Thus there is no differential pressure across the proportioning pumps which act, in effect, as "energised meters," and therefore there is no slip or tendency to unmeasured flow. Thus, regardless of the fluid viscosity or the flow rate, the accuracy of proportioning is maintained throughout the capacity range of the proportioning pump.

AIR ELIMINATION

The third and final factor affecting operation of the panel is elimination of air from the base stocks and additives. Failure to remove all the air means that it would be measured as a fluid, which would result in an incorrect product. The problem usually arises during the starting-up period when making a new blend, but it may also occur when storage tanks or additive drums have been pumped dry.

To prevent this, automatic air eliminators are provided on each oil and additive line between the booster and proportioning pumps. The presence of air in a stock line actuates the mechanism which stops the motor so that no proportioning pump can run. In addition the air eliminator starts to bleed off the air and switches on a red light to indicate which line is causing the trouble. As soon as all the air has been bled off or, if necessary, the feed switched from an empty tank to a full one, the red light goes out and the unit recommences to run.

The method of action of the air eliminators is as follows: each line contains a ball-float

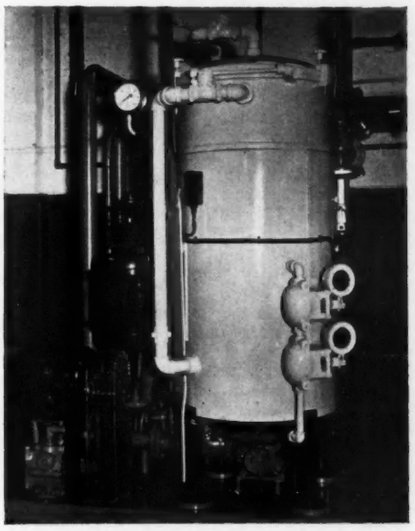


Fig. 2 The homogeniser, shown in section below, is contained in the upper half of this vessel; the lower half is a storage tank. The machine simultaneously completes blending of the components as well as dehydrating and de-aerating the oils.

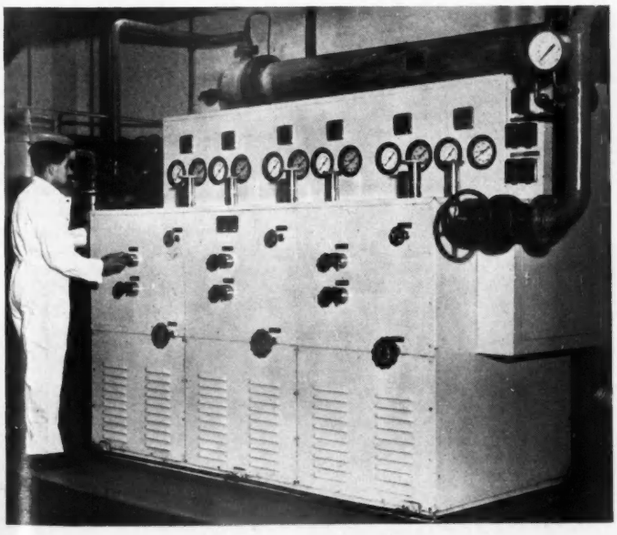


Fig. 1 The control panel of an automatic oil-blending plant. The required proportions of the blend components are obtained by adjusting the strokes of the delivery pumps. One motor is used to drive all six pumps which, as they operate at a common working pressure, act as "energised meters."

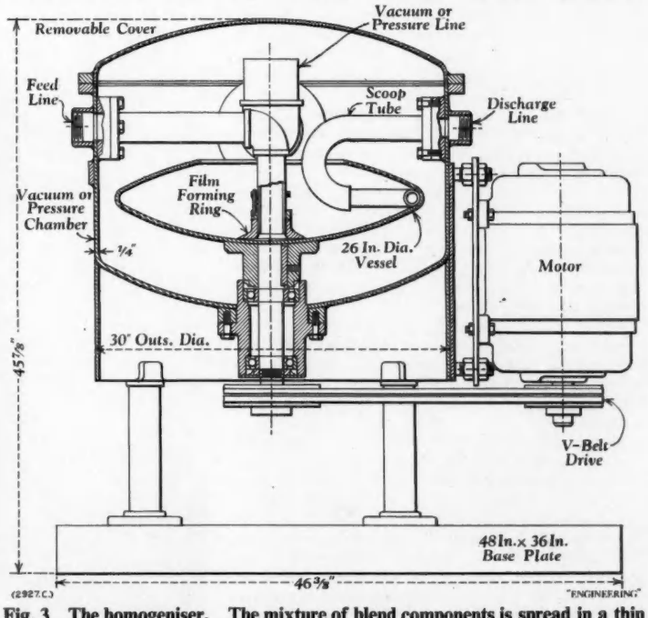


Fig. 3 The homogeniser. The mixture of blend components is spread in a thin film over the surface of the spinning mixing chamber. Reduced pressures dehydrate and de-aerate the oils which are intimately mixed by the rotating action and removed through the discharge scoop.

mechanically linked to an air-release valve and a single-pole double-throw microswitch. If air is present in the constituent supply line, it passes through the booster pump and into an air-eliminator trap. There it collects and displaces the oil in the trap, thereby lowering the oil level. With air in the trap, the ball float drops and opens the air release valve which allows the air to escape. When the ball float in the trap drops it also breaks the electric circuit on one side of the microswitch. This side of the microswitch is in series with a holding coil in the proportioning-pumps drive motor; when the circuit is broken the motor stops, so bringing the proportioning pumps to a standstill.

When the air in the trap causes the ball float to drop, the other side of the microswitch makes contact. This is in series with a red pilot light. Thus, when there is air in any one of the traps, a red light shows on the instrument panel and indicates which constituent line has air in it and has thereby caused the proportioning pumps to stop running.

When the source of the air in the constituent line has been discovered (such as a tank running dry) and the constituent supply restored, the booster pump will again pump oil into the air-eliminator trap. As the air in the trap is bled off through the air-release valve, the oil level will rise causing the ball float to rise. This will close the air-release valve so that no oil can leak through it and will close the microswitch on the side which is in the control circuit and open the switch on the side in the red pilot light circuit. Thus the red light will go out and the proportioning pumps will start running again.

In this way air is automatically eliminated during blending operations. The mechanism also ensures that air is evacuated from the empty constituent hoses each time the proportioning panel is started up on a new blend.

FILM HOMOGENISING UNDER VACUUM

On leaving the proportioning unit, the mixture of blend components is fed continuously to the homogeniser, where dispersion, de-aeration and dehydration are affected to complete the blending.

Operation of this section depends upon a film homogenising under vacuum conditions. The components are fed on to the face of a rapidly rotating hollow mixing chamber shown in section in Fig. 1. Turning in a horizontal plane about its axis, the chamber has a hole cut in its upper surface to allow entry for a vertical feed pipe. By means of a "film-forming" ring on the end of this supply pipe, a thin film of the blend components is fed continuously on to the lower concave surface of the chamber.

A vacuum of 27 in. of mercury or more is maintained in the enclosed space in which the mixing chamber rotates. From beneath the film-forming ring the oil flows out in a thin film on to the surface of the chamber. Becoming ever thinner in the process, this continuous attenuated film approaches a thickness of only 0·001 in. at the outer edge. The homogenised oil collects at the periphery of the mixing chamber and is forced out through a discharge scoop into a surge chamber.

While still a thin film, the oil is subjected to severe turbulence by virtue of the rotational, gravitational and frictional forces acting upon it. The combined effects of these forces produce the shear required for dispersion and blending.

Since homogenising is carried out at reduced pressure, all entrained air and traces of moisture are readily released from the continually changing oil surface. Where a measurable water content has to be removed, provision is made for heating the oil to about 150 deg. F. At this temperature the water can be readily distilled off. In contrast to the older types of batch blending plant, this new unit occupies little space, requiring no large agitators, kettles and de-hydrating plant. Film homogenising makes blending a "once-through" operation from base oil and additive storage to finished products.

TUBULAR STEEL TOWER FOR OFFSHORE TEST BORING

CONSTRUCTED TO WITHSTAND WIND AND SEA

The offshore boring unit which will be used by the National Coal Board to make test drillings for coal from positions off the coast was installed in its first drilling position on May 22. The boring unit consists of a tubular steel tower mounted on a cruciform base formed from two box-girders, with boring and accommodation decks at the top of the tower. The overall height of the tower to the top of the drilling rig is 184 ft., and its total weight, excluding reserve of drilling tubes, is 490 tons. The project was described briefly in ENGINEERING on March 5, 1954 (vol. 177, page 295), but the design of the model has been slightly altered in the finished tower. Consulting engineers to the project were Maunsell, Posford and Pavry, Abbey House, Victoria-street, London, S.W.1, who had considerable experience during the war in the construction and installation of naval and military sea forts round the coasts of Great Britain.* The main contractors were the Cleveland Bridge and Engineering Company, Limited, Smithfield-road, Darlington; Tube-wrights, Limited, Upper Brook-street, London, W.I, were appointed to produce the tubular members and the multi-branch junction pieces.

An illustration of the tower in course of construction is shown in Fig. 1, and an elevation in Fig. 2. Each leg of the four-sided tubular tower rests on top of a box-girder base, which can be seen in Fig. 1. Each of the two box girders of the cruciform base is 167 ft. 6 in. long, 7 ft. high, and 3 ft. wide. The weight of the base is 90 tons. It is internally braced and is divided into four airtight sections; these sections are filled with water when the tower is in position for drilling, but the water can be pumped out to give buoyancy when the tower is refloated for repositioning.

TUBULAR MULTI-BRANCH JOINTS

The tower has 80-ft. sides at the base, tapering to 40-ft. 68 ft. above the base. The 40-ft. square section then extends upwards for another 60 ft., but 20 ft. from the top further members branch out to support the girders forming the base of the working deck. The tubular members, of which there are only 90, 64 in compression and 26 in tension, were prefabricated at the Clyde Works of Stewarts and Lloyds, and were then sent to the site for assembly. There are 24 multi-branch joints, where from four to ten tubes meet; these joints have special internal plate diaphragms welded in to stiffen the fittings against the loads imposed by the branch connections.

At the four bottom corners, where the tower is bolted to the cruciform girder base, each joint has five branches composed of 24-in., 18-in. and 15-in. tubes. The compression members are flanged and bolted to the joints, while the tension members have double-jawed heel-pieces which are pinned to the single heel-piece on their respective joints. The four main 24-in. members run up to the next joint, 66 ft. above. Each of these four joints has six branches: two for the 24-in. members and four for the 18-in. members, which taper to 16 in. at the joint. The purpose of tapering the tubes is to allow the branch stubs to be joined to the large-diameter tubes with good welded connections.

At the four next main joints, 20 ft. below the main deck, there are ten branches, and again some of the members are tapered to make good welded connections. The problems of branch pieces in pipes were discussed in a series of articles by Dr. J. S. Blair, D.Sc., M.I.Mech.E., general manager of the Department of Research and Technical Development Branches of Stewarts and Lloyds, which appeared in ENGINEERING between July and December of 1946 (vol. 162, pages 1, 217, 508, 529, 553, 577 and 605). The illustration in Fig. 3 shows one of the ten-branch joints with flanges and heel-pieces. The ends of all the joint stubs and tube members are sealed off with steel plates to prevent corrosion, and as they are designed to work in 80 to 120 ft. of water, all were tested before the final sealing at pressures from 50 to 100 lb. per square inch, according to the diameter of the tube. Bitu-

* "The Construction of Britain's Sea Forts," J. A. Posford. *The Civil Engineer in War*, vol. 3, page 132, published by the Institution of Civil Engineers.

Fig. 1 One of the accommodation units of the offshore boring tower being hoisted into position. In the far left background can be seen the Forth Bridge.

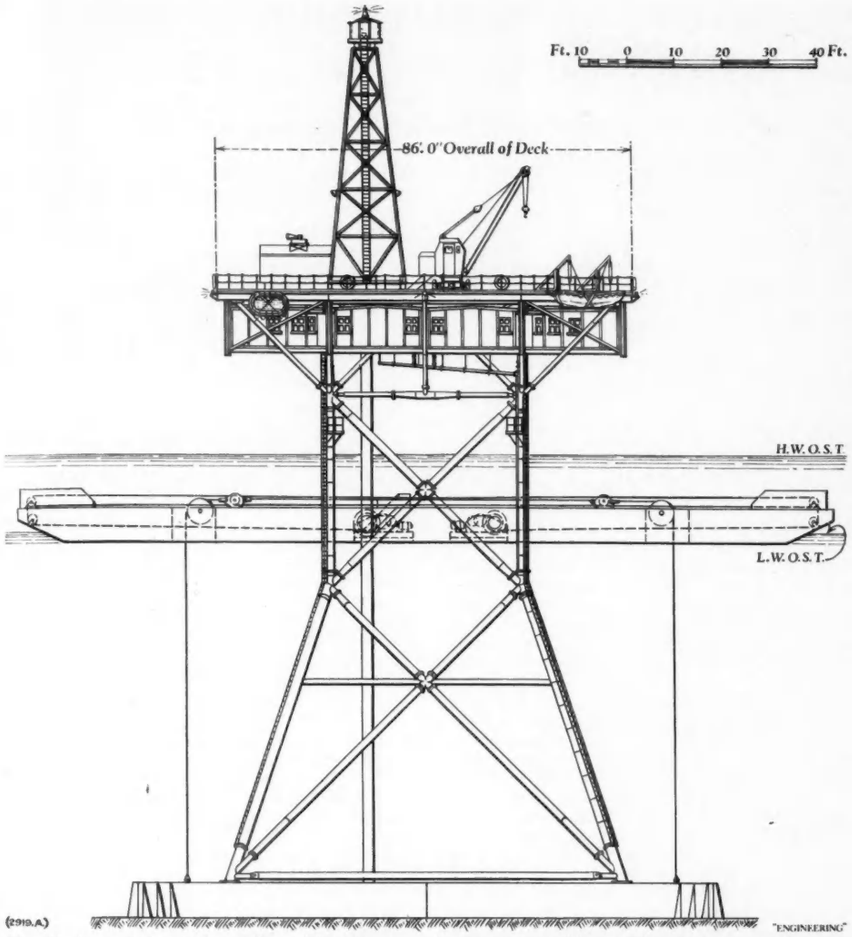


Fig. 2 One of the pontoons for raising the tower is shown in position. The winches are driven by electric motors which are supplied through cables from the generators on the tower. The guard tube for the drill can be seen extending below the drilling rig.

mastic paint has been used on the tubes and girders as protection against corrosion.

There were several reasons for the tubular construction of the tower; the tubes offer less resistance to the elements, and in the drilling positions the tower may have to withstand gale-force winds; the smaller surface area reduces water pressure on the submerged parts of the tower; the tubular construction also gives a substantial reduction in weight compared with the more orthodox structural steel methods. Tubes of large diameter were used, which allowed the structure to be made from relatively few members, thus lowering resistance to wind and sea still further. In Fig. 1 the Forth Bridge can be seen in the far left background. The tubular structure of that bridge was made by bending plates and riveting them; it is interesting to speculate how such a bridge would have been constructed had the modern techniques used in the N.C.B.'s drilling tower been available between 1883 and 1890. [For a comprehensive account of the Forth Bridge, see ENGINEERING, February 28, 1890 (vol. 49, page 213).]

The tower as at present constructed can be used in a seaway up to depths of about 80 ft. It has been designed to withstand an 80-m.p.h. gale and waves of up to 30 ft. If it is required to be moved to a distant site it can be dismantled and moved in pieces; this is one reason why the members are flanged and bolted to the joints, as Fig. 3 shows, instead of being welded.

WORKING AND ACCOMMODATION DECKS

The octagonal working deck is 130 ft. above the sea bed and its maximum overall dimension is 86 ft. On the working deck is the drilling rig, 54 ft. high, with its own Diesel engine, a 2-ton mobile crane, and a workshop and pump house. There is also storage space for the tubes and rods required for drilling. A tubular casing of flanged sections, 145 ft. long and 24 in. in diameter, weighing about 8 tons, will guide the drill to the sea bed. Welded to the end is a case-hardened shoe to bite down into the sea bed. The guard tube, which can be seen in Fig. 2, extending from below the drilling rig, acts as a caisson, and boring can be carried out in much the same way as test boring on land. When the tube is lowered it will be guyed to ensure that it goes down without any deviation from the vertical, and when in position it will be braced to the main members of the tower at a point between the high and low water marks.

The accommodation deck is slung below the working deck, and just below the working deck and above the top of the accommodation units are the fuel and water tanks. The six accommodation units, one of which is shown being hoisted into position in Fig. 1, each consist of four cabins, a bathroom or shower, and a w.c. In two of these the radio room and the first-aid room take the place of the bathroom. There are two more units, one of which contains the boremaster's suite, the office, and the mechanical and electrical stores, and the other the recreation room. In the centre section of the accommodation deck are the galley and messroom, and generator room. All the units are thermally insulated and are made to withstand the high winds to which they may be subjected.

AUXILIARY EQUIPMENT

There are three self-contained electric generating sets, which provide all the power and lighting required on the tower, except the power for the drilling rig. Two sets can supply all the power required, so that there is always one standby set in case of breakdowns. The Diesel engines were made by Crossley Brothers, Limited, Openshaw, Manchester, 11, and have a rated horse-power of 100 brake horse-power at 500 r.p.m. The generators were made by Crompton Parkinson, Limited, Guiseley, Yorkshire, and give an output of 50 kW at 440/220 volts direct current on a three-wire distribution system.

There are two seawater pumps of the injector type which can provide the whole of the needs of the unit, namely: supply to distillation plant, water for w.c. flushing, and water for the drilling rig. One pump is driven by a 1½-h.p. motor and delivers 700 gallons per hour, while the other is driven by a 3-h.p. motor and delivers 1,200 gallons per hour. The distillation plant converts seawater into palatable fresh water at a rate of 42 gallons per hour, and absorbs a power of 10 h.p. It provides for all normal drinking, cooking, and washing requirements. The galley equipment includes cooking range, griller, boiling pan, potato peeler and refrigerator, all electrically operated.

A radio telephone provides communication with the shore base, which will be at Kirkcaldy for the first drilling position. The transmitter receiver on the tower works at 12 volts, and that at the shore base at mains voltage. The shore base equipment can be switched into circuit with the G.P.O. telephone exchange for use at night. Other auxiliary equipment includes the flashing lights to indicate the tower's position, and the lifeboat and raft for use in emergencies.

MOVING THE TOWER

The method of raising the tower to move it from one drilling position to another can be most easily understood by reference to Fig. 2. Two pontoons, each 170 ft. long, 17 ft. 6 in. wide, and 7 ft. deep, are positioned parallel to two opposite sides of the tower. Twin lifting strops, each 129 ft. long and with a breaking load of 213 tons, are lowered from each end of the two pontoons to the four outside ends of the cruciform base. They are attached to lugs on the box girders, which are shown in Fig. 2, and which can just be seen in Fig. 1. When the tower is being raised the job of attachment

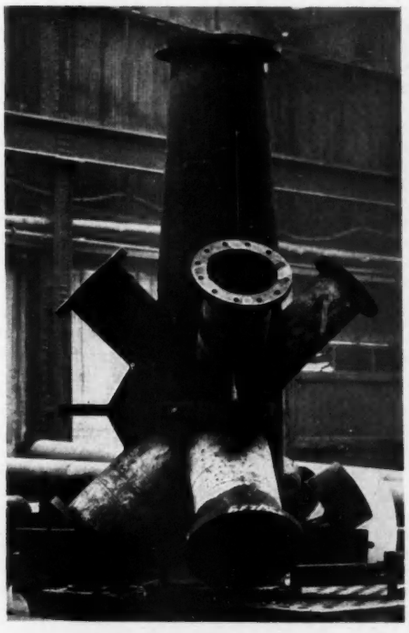


Fig. 3 The tower is made of tubular steel. The main members are 24 in. in diameter, and the tube junctions are welded. The junction in the illustration has ten branches, and is one of the four 20 ft. below the working deck.

must be done by divers in diving suits. The strops are connected, via a 7 : 1 reduction, to electrically-driven winches shown in Fig. 2. The electricity supply for the winch motors is from the tower through a cable let down on to the pontoon and connected through a switch pillar. When the tower is ready to be raised the water is blown out of the air-tight compartments of the cruciform base by compressed air. The compressed air is supplied by an independently-driven compressor which is mounted on one of the pontoons. The compressed air is led from the compressor to a manifold on the tower, from where it is admitted through valves to the air-tight compartments.

Buoyancy of 200 tons is achieved by pumping out the base of the tower, and this, combined with the buoyancy of the pontoons, enables the tower to be lifted up from the sea bed until it reaches the travelling position. To secure the pontoons and keep them in alignment while the tower is being towed by tugs from one position to another, two steel tubular booms, each 18 in. in diameter and 94 ft. 6 in. long, are fixed across the ends of the pontoons.

When a new drilling position is chosen the sea bed must be surveyed to ensure that it is level. Lowering the tower follows the reverse procedure to raising, and when the tower is on the sea bed water is admitted to the air-tight compartments of the base to give increased stability.

The tower will be used by the Foraky Boring and Shaft Sinking Company, Limited, the Nottingham Colwick Estates, Nottingham, to make test borings for coal at positions in the Firth of Forth near Kirkcaldy. There are large reserves of coal beneath the sea off the coasts of Britain, but precise knowledge is needed about their depth, thickness and quality before new mining operations can be planned. The same boring technique will be used from the tower as is used for test borings from positions on land. When borings are completed at one point the tower will be moved to a new position for further test borings.

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PRODUCTION OF OIL ENGINES

The demand for static Diesel engines was emphasised by the unveiling ceremony of the 100,000th Petter AV Diesel Engine on May 23. These engines, produced by Petters, Limited, Staines, are used in large numbers for agricultural purposes, and it was therefore appropriate that the unveiling should have been performed by Sir James Scott Watson, C.B.E., former Chief Scientific and Agricultural Adviser to the Ministry of Agriculture and Fisheries. Introducing Sir James, Mr. Miles Beevor, managing director of the Brush Group, Limited, said that the present range of AV water-cooled engines went into production in 1947, and average production since then had been 250 per week. Sir James spoke of the great use that such engines had been in the mechanisation of agriculture, the objective of which was to produce more at less cost in human toil, and also mentioned the uses of such engines in the fishing industry.

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RULING PEN WITH RESERVOIR HANDLE

Long lines up to $\frac{1}{4}$ in. wide can be ruled easily and accurately with the "Anderson" ruling pen made by Vetry, Limited, Boreham Wood, Hertfordshire. The handle of the pen is a transparent ink reservoir, from which the ink flows by way of the centre sliding blade to the nib. The centre blade serves several purposes: it cleans and laps the two inner surfaces of the nib; it provides sufficient but controlled flow of ink for drawing thick lines; by its sliding action it prevents ink congealing in the feeder tube. The width of line is variable from a fine hair line to $\frac{1}{4}$ in.

THREE IMPROVEMENTS IN RAILWAY SIGNALLING

WORK ON LONDON UNDERGROUND AND MAIN LINES

Two recent improvements in colour-light signalling on main-line railways are the completion of the Southern Region's programme between London and Brighton, and the introduction of multi-aspect working on the Western Region. The third development recorded here is the introduction by London Transport of a remote-controlled interlocking machine that has replaced the locally-operated frame at Aldersgate station.

SOUTHERN REGION PROGRAMME COMPLETED

On the morning of May 8, the fourth and last stage in the provision of colour-light signalling between Battersea Park Junction, Bricklayers Arms Junction and Coulsdon North was put into action. This means that the whole of the Southern Region's track between Victoria, London Bridge and Brighton is now signalled in this way. Stage 4 covers the area from East Croydon to between Purley and Coulsdon North; it is used by over 5,600 trains each week. Reports of the earlier stages have already been given in ENGINEERING (vol. 170, page 436, 1950, and vol. 177, page 422, 1954). In all, the scheme has taken six years to complete and has cost about £2 million.

With the beginning of the general extension to the then Southern Railway's suburban and outer suburban electrification in the middle 'twenties, the decision was taken to adopt power—and a certain amount of automatic—signalling at and around the London termini where the traffic, already very heavy, could be expected to increase considerably and soon outgrow the capacity of the mechanical installations. Some of the latter were very large and cumbersome, and included a number of signal-boxes, often close together, which were costly to man. In 1919, after the 1914–18 war, the South Eastern and Chatham Railway had applied all-electric signalling with three-position semaphores to its own half of Victoria station, but by the time electrification became extended to the routes which belonged originally to that company, the colour-light signal had been developed for long-range day service.

The system selected utilised four-aspect indications, and had been developed by Mr. W. J. Thorrowgood (at that time Signal Engineer of the Southern lines) and recommended by a committee of the Institution of Railway Signal Engineers which had been specially appointed to investigate multi-aspect signalling. This was chosen as the lines carried mixed steam and electric services, and it was essential to provide for two different braking distances if safety was to be assured and the steam-train drivers to be able to run with confidence in the electrified areas. Holborn Viaduct, Cannon Street and Charing Cross stations were converted to the new system in 1926, London Bridge and some lines to the south in 1928, and during 1927 the old South Eastern lines to New Cross and St. Johns were equipped, with a great saving in operating costs and an appreciable speeding up of the traffic.

In 1930 it was decided to electrify to Brighton, a step contemplated by the old Brighton Railway Company but brought to nothing by the first World War. The line south of Coulsdon was well suited to automatic signalling, while the mechanical signal-boxes at Brighton, some of which were 50 years old, could be replaced by modern electrical equipment to great advantage. The work was therefore ordered, and was completed throughout by the middle of October, 1932, the full electric service being put into operation on January 1, 1933. Many signal boxes were abolished and others kept normally closed, so that eight now did the work for which 39 had formerly been required. With the exception of the Brighton station area, no large interlocking layout was involved, although at Three Bridges the Central box took over the work formerly done by the North and South boxes.

The sections north of Coulsdon, however, to London Bridge and Victoria, involve a number of junctions, some rather complicated, and numerous siding connections. The approach lines from near Clapham Junction to outside Victoria were nevertheless equipped by 1938 and the terminus itself, on the Brighton line side, in 1939. By this time similar work had been completed at Waterloo station on the former L.S.W.R. section, and thence to just beyond Surbiton.

War again caused a long delay, but as soon as possible thereafter the task was resumed and the work pushed forward as energetically as circumstances would allow. In October, 1950, the new signalling was taken through from New Cross Gate to the north end of Norwood Junction and two years later from Battersea Park to Selhurst. The complicated junction area south of the latter place, connecting it with Norwood Junction and West and East Croydon, was changed over in March, 1954, exactly 28 years after the introduction of four-aspect colour-light

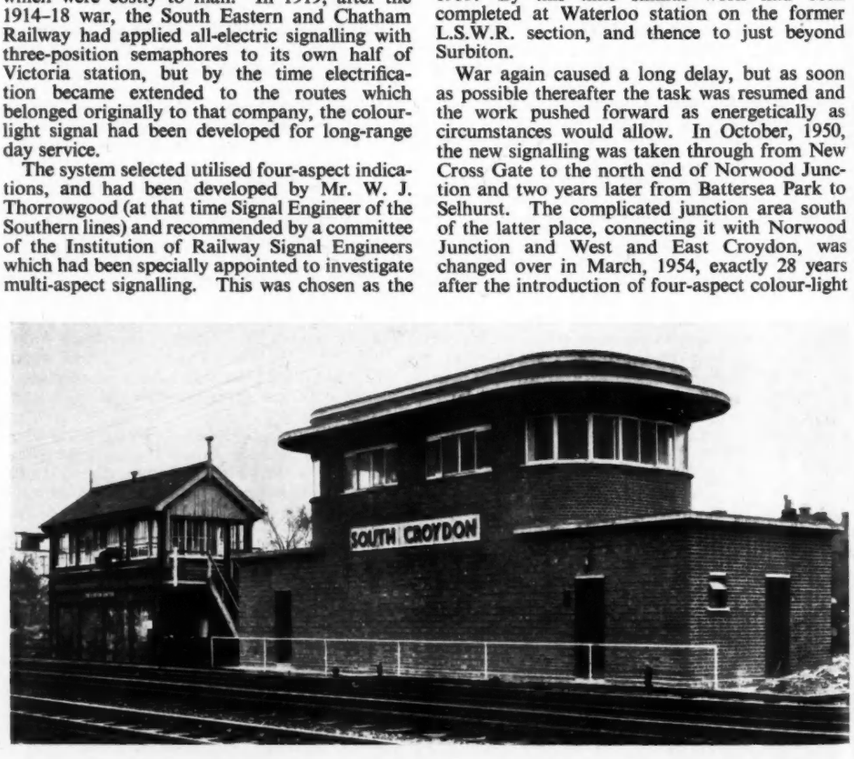


Fig. 1 Colour-light signalling is now continuous from Victoria (Central) and London Bridge to Brighton. One of the eleven new signal-boxes is shown here standing to the right of one of the 32 old boxes that have been replaced since the war

Fig. 2 In the new East Croydon box of the Southern Region there is an electric frame with 103 levers. At each end are the train describers and in the middle the track diagram.

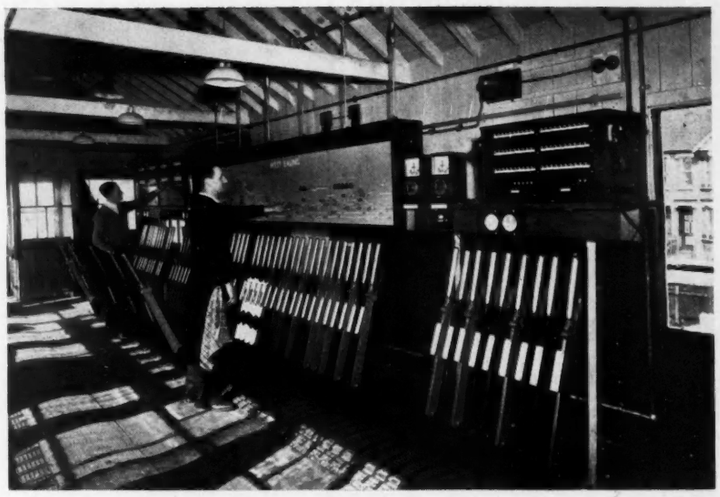


Fig. 3 Although multi-aspect colour-light signals have been installed, mechanical levers have been retained in the West Ealing box of the Western Region. Through route control is given by the switches on the main indicator diagram.

signalling at Holborn Viaduct. These three post-war stages eliminated 25 mechanical signal-boxes and replaced them by eight electrical boxes. Finally, on May 8 last, the gap from East Croydon to Coulsdon was bridged.

In the area that has just been finished, three new signal-boxes, at East Croydon, South Croydon and Purley, replace seven old ones. In them, 205 levers in all-electric frames replace 464 manual levers; the section between South Croydon and Purley is covered entirely by automatic signals. The standard interval for stopping trains of 2 to 2½ minutes headway has been maintained in accordance with the earlier arrangements. The signal-boxes are of the new standard type of the Southern Region and have been described in detail in the earlier articles, but the interior of the East Croydon box is illustrated in Fig. 2. This shows the 103-lever frame with the train describers and the route diagram. The exterior of the box at South Croydon is illustrated in Fig. 1, together with the old one that it replaces. In this last stage there are 70 multiple-aspect signals, 60 solenoid-operated shunting discs, and 100 point machines. The changeover was carried out by nearly 500 men within a 7½-hours possession of all lines in the area.

Reviewing the four stages as a whole, eleven new signal-boxes with all-electric power frames, totalling 841 levers, have replaced 32 manual-frame boxes, totalling 1,515 levers. Over the 117 track miles (27 route miles) there are 400 multiple-aspect signals, of which 100 are automatic, spaced to provide a 2 to 2½ minute headway for following stopping trains. Drivers now have a uniform system of signalling from either London terminus to Brighton; the additional safety afforded by continuous track-circuiting is obtained, together with the great operating advantages offered by the colour-light signal in terms of improved visibility and the adoption of multiple-aspect working.

The scheme was prepared and the whole of the installation carried out by the staff of the Southern Region Signal Engineer, Mr. L. J. Boucher, under his New Works Assistant, Mr. C. F. Challis.

WESTERN REGION INTRODUCE FOUR-ASPECT SIGNALS

When in 1931 the former Great Western Railway introduced colour-light signalling on its main line out of London as far as Southall, it did not follow the practice adopted by the other railways of using the multiple-aspect principle, except at a few special locations. Instead, it merely replaced the existing semaphores by light units of the "searchlight" type giving the same indications as the mechanical signals, and made no alteration in the general method of operating the line. The drivers had nothing new to learn, and the signalmen's work remained unaffected.

After the war, it became necessary to renew the Paddington-Southall signals and opportunity was taken to re-arrange the signalling throughout on the multiple-aspect system in order to get more flexible traffic working, reduce the number of signal-boxes, and instal improved track circuiting controls at minimum expense. It proved too costly to put in a number of power signal-boxes, as was at first envisaged, and the Signal Engineer, Mr. A. W. Woodbridge, in consultation with the Chief Operating Superintendent, designed a scheme which could be carried out as a renewals equivalent, retaining the existing mechanical-type signal-boxes except where it would pay well to abolish them. The short distances between most of the boxes necessitated a number of special controls being designed to give the correct spacing and sequence of aspects for the through-running signals and to retain adequate overlaps for the protection of crossing or shunting movements. Block telegraph working being superseded by describers and illuminated diagrams, special circuits were arranged to give due warning of the approach of trains and avoid any delay in the clearing of signals.

The new working was brought into use between Acton and Hanwell during a recent week-end, four signal-boxes being closed and the control over the length of route concerned being concentrated in the box at West Ealing. Here a new mechanical lever frame has been provided for working points and other functions in the vicinity. Over this is a panel for operating electrically all the remaining functions in the area points, signals, etc. The "entrance-exit" principle is used in which the signalman has only to actuate two small switch knobs on the diagram at the beginning and end of a route to cause it to become set up, and the signals for it to clear provided conditions permit. Through working, however, can be rendered purely automatic at will, and this much reduces the signalmen's work. The track circuits here have been changed from direct-current to alternating-current operation, but this will not necessarily be done everywhere.

An interesting feature of the work of installation was that the change from the old to the new signalling, which involved the removal of 56 old signal posts and associated equipment, was directed by both ordinary telephone and by wireless communication with "walkie-talkie" sets from a coach in a siding, where progress reports were received and any instructions required to supplement the printed ones given. The demolition trains were directed entirely by wireless. The route is equipped with the well-known Western Region type automatic train control, and a number of new contact ramps were required, while others were moved to new positions or abolished. About 250 Signal Department staff were engaged on the change-over, which was effected in time to enable all lines to be handed back to the Operating Department by 2.30 p.m. on the Sunday afternoon.

REMOTE CONTROL SIGNALLING AT ALDERSGATE

Renewal of the signalling equipment in the vicinity of Aldersgate on the Circle Line has been carried out by London Transport, utilising remote-control equipment of a new type. The signalling of the section was formerly controlled from Aldersgate signal-box, the equipment being of electro-mechanical type, with mechanical levers for the points, slides for the signals and electrical interlocking. In addition to the main line traffic on the Circle Line, a section of the widened City lines was controlled, and there were connections to sidings. The new equipment, which is remote controlled from Farringdon signal-box, permitting the elimination of the Aldersgate box, is the latest of a series of advances which have been made in London Transport signalling equipment over recent years.

Between the two wars a few installations, the largest being at Earls Court, were constructed in which, while the lever frame was retained, the point levers did not normally require to be moved, being locked in a neutral condition and used only in an emergency. Separate "route levers" of the push-and-pull type served to set up, by a single movement, a complete route and clear the necessary signals. Subsidiary signal-boxes, not ordinarily manned, could be controlled if required from these frames, which had relay interlocking with a certain amount of mechanical locking in addition. This equipment also worked satisfactorily but was more complicated than the earlier type. In an endeavour to obtain improved working while retaining the simplicity of the earlier standard signalling circuits, the "power-operated lever" system was designed, actuated by remote control. In this, a lever frame was still used but its levers normally were moved to and fro not by hand but by a pneumatic drive, itself under the control of route levers in another frame which could be at any distance away required.

The operation of power-worked signal levers by remote control was first carried out at Shoreditch in 1944, and subsequent installations of similar type were made at North Acton, Hainault, Ruislip and Harrow-on-the-Hill. When the Ealing Broadway signalling was renewed in

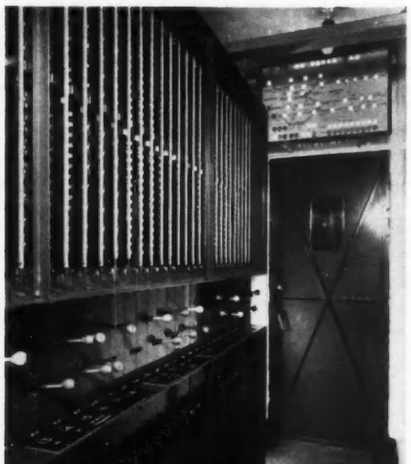


Fig. 4 In London Transport's remote-control interlocking signal frame; the vertical shafts, carrying electrical and mechanical interlocks, are rotated by compressed-air cylinders.

1952 there was a further development, the remote-controlled equipment being adapted for operation from a push-button control desk. A second installation of this type was made in 1954, at Wembley Park. In the new Aldersgate installation the development has been carried a stage further. The lever frame has now been dispensed with and a new "interlocking machine," controlled by push-buttons from the signal-box at Farringdon, has been designed to take its place.

The interlocking machine, which is illustrated in Fig. 4, is of a simple vertical design with 36 upright shafts, each operating one signal or point function. Provision is made for mechanical interlocking between the shafts. At the base of each shaft two small compressed-air cylinders supply the rotational movement. Immediately above the compressed-air cylinders is the mechanical locking. Above this an electrical lock provides the back locking and track locking, and at the top of the machine are a set of contacts for controlling the signal and point circuits. The Aldersgate interlocking machine operates 20 signals and 14 sets of points and is controlled by a small auxiliary push-button panel in the Farringdon signal-box, which has 23 buttons for 19 routes.

The interlocking machine, instead of being an adaptation of previous apparatus to suit remote control, is specifically designed for its purpose. Its advantages over the previous remotely-controlled signal lever-frames include economy, simplicity and space saving, combined with full efficiency in performance. It is believed to be the first of its kind to be introduced in railway signalling. In the course of its development a complete change has been made in the design of the mechanical locking. Instead of being a fitter's hand-made job as previously, the present design provides for the mechanical locking to be assembled from a set of standard components, and only a screwdriver is required for assembling. If an alteration is necessary, it can be carried out in a short time and without fitting work.

Following the Aldersgate installation, it has been decided to provide three interlocking machines in connection with resignalling at Camden Town (Northern Line) during 1955, and the system is likely to be extensively employed elsewhere. The machine, which has been patented, was designed in the Signal Department of London Transport, detailed designing having been done for the Executive by the Westinghouse Brake and Signal Company, Limited, 82 York-way, London, N.1.

Labour Notes

DOCK STRIKE

Efforts to avert the strike of dock workers at English ports, called by the National Amalgamated Stevedores and Dockers for Monday last, continued throughout the week-end. Both Sir Walter Monckton, the Minister of Labour, and Sir Wilfred Neden, the Ministry's chief industrial commissioner, have played leading parts in the efforts to secure peace, and they have been well supported by the Trades Union Congress, the Dock Labour Boards and the port employers.

The trouble is due, in the main, to an inter-union dispute between the Transport and General Workers' Union and the N.A.S.D., which seeks to be recognised as a fully-negotiating body in the dock industry at Hull, Birkenhead, Liverpool and Manchester, in the same way that it now is in London.

During recent months, the N.A.S.D., which has a membership of about 7,000 in the Port of London, has been recruiting new members at these four northern ports, principally, it is alleged, from the ranks of the other union. It is claimed by the T.G.W.U. that this action was begun during a previous dock strike, in which members of that union were involved.

The N.A.S.D. is stated to have previously restricted its activities to London, and only the T.G.W.U. is represented on local joint committees of the industry at other ports. With the formation by the N.A.S.D. of outposts at the northern ports, the strength of which has not been disclosed, the union considers that it should be granted the right to elect representatives on to the local committees of employers and dock workers, and thus become fully recognised at those centres.

T.U.C. ATTITUDE

An interview between the general purposes committee of the T.U.C. General Council and leaders of the N.A.S.D. took place on May 18.

The officers of the N.A.S.D. were informed that discussions with their union could only take place provided that it withdrew from the position it assumed last autumn. This, it was explained, would involve the return of members previously belonging to the T.G.W.U., assurances that the union would refrain from encroaching on the membership of the T.G.W.U. and that it would abide by the rules of the T.U.C. governing inter-union relationships, and a promise that the findings of a disputes tribunal to be set up by the T.U.C. General Council would be accepted.

It may be recalled that it was because the union did not accept similar conditions last autumn that it was suspended from affiliation to the T.U.C.

These proposals were placed before a meeting of the full executive committee of the N.A.S.D. on the following day, when the committee decided unanimously that the suggestions were "completely unacceptable" to the union as a basis for securing a settlement satisfactory to its membership.

A statement was issued immediately afterwards by the General Council calling upon all dock workers, and all who had the genuine interest of the trade-union movement at heart, not to encourage or support the N.A.S.D. in its efforts to bring about a stoppage of work. It was declared that the union's demands for a strike were not for, but against, "good trade-union principles and practice."

DECISION RESTS WITH THE UNIONS

A statement issued on May 19 by the National Joint Council for the Port Transport Industry, on which both sides of the dock industry are represented, declared that it condemned the proposed strike action "in the strongest possible terms."

The National Joint Council stated that it was anxious that all men in the industry should be properly represented on the local and national Joint Councils through their responsible trade unions, but that this must be a matter for all the unions concerned to determine for themselves.

The trade-union side of the National Joint Council comprises representatives of the Transport and General Workers' Union, the Scottish Transport and General Workers' Union, and the National Union of General and Municipal Workers. The N.A.S.D. was represented until last year.

The N.A.S.D., it was stated, "had repeatedly defied the conciliation processes laid down jointly by the employers and the unions, including the N.A.S.D. itself."

RAILWAY STRIKE THREATENED

Recent discussions on wage rates for railway footplate staffs, between the British Transport Commission, on the one hand, and leaders of the Associated Society of Locomotive Engineers and Firemen and the National Union of Railwaymen, on the other, broke down on May 19, and the former union decided on the following day to call a strike of its members for midnight on Saturday.

A representative of the Commission, speaking after the ending of the negotiations, said that the A.S.L.E.F. had repeated its former demands for increases in wage rates, ranging from 1*s.* 6*d.* to 5*s.* 6*d.* a week, in order to restore the differences between footplate men's wages and the rates for other railwaymen, which had existed between November, 1954, and January last.

The Commission had then offered to adjust the rates of certain classes of drivers, so as to relate their wages more closely to their skill and responsibility. It was suggested that all train operating should be divided into two groups. Drivers and motormen working the more important services would receive an additional 5*s.* a week and those working the others, an additional 2*s.* 6*d.* a week.

The A.S.L.E.F. declared the Commission's proposals to be quite unacceptable.

RAILWAY PRODUCTIVITY COUNCIL

The composition and terms of reference of the newly-formed British Railways Productivity Council were announced by the British Transport Commission on May 19. It is expected that the Council, to the establishment of which Mr. Harold Watkinson, Parliamentary Secretary of the Ministry of Labour and National Service, referred in answer to a parliamentary question on March 15, will hold its first meeting next month.

Nine members of the Council will be appointed by the British Transport Commission and three by the National Union of Railwaymen. The other three unions catering for railway employees, the Associated Society of Locomotive Engineers and Firemen, the Transport Salaried Staffs' Association and the Confederation of Shipbuilding and Engineering Unions, will each elect two representatives to serve on the new organisation.

The Council will initiate general proposals for improving efficiency, including the best use of manpower, to advise on matters concerning the modernisation plan, to review the railways' joint consultative machinery, to advise the Commission on ways of publicising its aims and achievements among railway employees, and to advise the Commission on using the services of such bodies as the British Productivity Council and the British Institute of Management.

INCREASE IN COST-OF-LIVING INDEX

There was an increase by one point in the level of the interim index of retail prices during the period between March 15 and April 19, according to an announcement by the Ministry of Labour and National Service on May 19. The index figure stood at 147 on April 19, compared with 146 on March 15 and 142 in mid-April last year.

The index figure for April 19 is the highest so far recorded. It had been stable at 146 for the first three months of this year, after increasing by one point, from 145, in November and December, 1954. The index was introduced on June 17, 1947; the level of prices on that date being taken as 100.

FORTHCOMING EXHIBITIONS AND CONFERENCES

This list appears in the last issue of each month. Events appearing for the first time, and alterations of dates, places, etc., are indicated by an asterisk (*). Particulars of forthcoming exhibitions and conferences not included below may have appeared in ENGINEERING, *March 25, page 386; or April 29, page 546. Organisers are invited to send to the Editor particulars of forthcoming events as soon as arrangements are made.*

METALLURGICAL SOCIETIES' JOINT MEETING IN EUROPE.—Wed., June 1, to Tues., June 7, in London and British centres; Thurs., June 9, to Sun., June 12, in Düsseldorf, Germany; Mon., June 13, in Liége, Belgium; and Tues., June 14, to Sat., June 18, in Paris and French centres. Open to members of British, West European and American metallurgical societies. Apply to the Iron and Steel Institute, 4 Grosvenor-gardens, London, S.W.1. Tel. SLOane 0061. See ENGINEERING, April 15, page 459.

BATH AND WEST AGRICULTURAL SHOW.—Wed., June 1, to Sat., June 4, at Launceston, Cornwall. Organised by the Bath and West and Southern Counties Society, 3 Pierrepont-street, Bath. Tel. Bath 3010.

BRITISH PLASTICS EXHIBITION.—Wed., June 1, to Sat., June 11, at Olympia, London, W.14. Organised by "British Plastics," Dorset House, Stamford-street, London, S.E.1. Tel. WATerloo 3333. See ENGINEERING, March 25, page 384.

CENTENARY OF ALUMINIUM EXHIBITION.—Wed., June 1, to Sat., June 11, at the Royal Festival Hall, London, S.E.1. Organised by the Aluminium Development Association, 33 Grosvenor-street, London, W.1. Tel. MAYfair 7501. See ENGINEERING, February 11, page 164.

WORLD PETROLEUM CONGRESS.—Mon., June 6, to Wed., June 15, in Rome. Apply to the British National Committee, 26 Portland-place, London, W.1. Tel. LANgham 2250.

BUSINESS EFFICIENCY EXHIBITION.—Mon., June 6, to Thurs., June 16, at Olympia, London, W.14. Organised by the Office Appliance and Business Equipment Trades Association, 11-13 Dowgate-hill, London, E.C.4. Tel. CENtral 7771.

*TOBACCO MACHINERY EXHIBITION.—Mon., June 6, to Thurs., June 30, at the firm's Saunderton, Bucks, factory. Arranged by Molins Machine Co., Ltd., Evelyn-street, London, S.E.8. Tel. BERmondsey 1961.

BUILDING PLANT EXHIBITION.—Wed., June 8, to Wed., June 15, at the Queenslie Industrial Estate, Glasgow. Organised by the Ministry of Works, Lambeth Bridge House, London, S.E.1. Tel. RELiance 7611. See ENGINEERING, December 10, 1954, page 773.

AVIATION DISPLAY AND STATIC EXHIBITION.—Fri., June 10, to Sun., June 19, at le Bourget Airport. Organised by the Union Syndicale des Industries Aéronautiques, 4 Rue Galilée, Paris, 16e.

*HYDRAULICS CONFERENCE (6TH).—Mon., June 13, to Wed., June 15, at the Iowa Institute of Hydraulic Research, Iowa, U.S.A. Theme: "Flow Measurement." See ENGINEERING, April 29, page 532.

WELDING TECHNICIANS' ANNUAL CONGRESS.—Mon., June 13, to Thurs., June 16, at Frankfurt-on-Main. Organised by the German Welding Society, Harkortstrasse 27, Düsseldorf.

CONFERENCE ON COMBUSTION.—Wed., Thurs. and Fri., June 15, 16 and 17, at Cambridge, Mass., U.S.A. Organised by the American Society of Mechanical Engineers, 29 West 39th-street, New York, 18; and Tues., Wed. and Thurs., Oct. 25, 26 and 27, in London. Organised by the Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1. Tel. WHItehall 7476. See ENGINEERING, September 24, 1954. page 398.

CONFERENCE ON AUTOMATIC FACTORIES.—Thurs., June 16, to Sun., June 19, at Margate. Organised by the Institution of Production Engineers, 10 Chesterfield-street, London, W.1. Tel. GROsvenor 5254. See ENGINEERING, November 26, 1954, page 683.

*INTERNATIONAL POWDER METALLURGY CONGRESS.—Mon., June 20, to Thurs., June 23, at Reutte, Tyrol, Austria. Sponsored by Dr. Paul Schwarzkopf, President of the American Electro Metal Corp., Yonkers, N.Y., U.S.A. The theme will be "High-Temperature and Corrosion-Resistant Materials by Powder Metallurgy." Apply to George Cohen Sinteel Ltd., a subsidiary of the 600 Group of Companies, Broadway Chambers, Hammersmith, London, W.6. Tel. RIVerside 4141.

NON-DESTRUCTIVE TESTING CONGRESS.—Wed., June 22, to Sat., June 25, at the Royal Technical College, Glasgow. Summer Meeting, Non-Destructive Testing Group, Institute of Physics, 47 Belgrave-square, London, S.W.1. Tel. SLOane 9806.

SAFETY AND FACTORY EFFICIENCY EXHIBITION.—Fri., June 24, to Fri., July 1, at Bingley Hall, Birmingham. Information from the Industrial Safety Training Centre, Museum of Science and Industry, Newhall-street, Birmingham, 3.

BUILDING AND PUBLIC WORKS MATERIALS AND EQUIPMENT EXHIBITION (FIRST INTERNATIONAL).—Sat., June 25, to Sun., July 10, at Domaine National de St. Cloud, Paris. Exhibition offices: 29 Rue Cambon, Paris.

AMERICAN SOCIETY FOR TESTING MATERIALS.—Sun., June 26, to Fri., July 1, at Atlantic City, N.J., U.S.A. Annual meeting, arranged by the Society, 1916 Race-street, Philadelphia 3, Pa., U.S.A.

BRITISH ELECTRICAL POWER CONVENTION.—Mon., June 27, to Fri., July 1. Meetings at The Dome, Brighton. Exhibition at the Sports Stadium, West-street, Brighton, organised by the British Electrical Development Association, 2 Savoy-hill, London, W.C.2. Tel. TEMple Bar 9434.

BRITISH INSTRUMENT INDUSTRIES EXHIBITION.—Tues., June 28, to Sat., July 9, at Earl's Court, London, S.W.5. Organised by F. W. Bridges and Sons, Ltd., Grand Buildings, Trafalgar-square, London, W.C.2. Tel. WHItehall 0568.

MACHINE TOOL EXHIBITION.—Mon., July 4, to Sat., July 9, at Sydney. Apply to the Sydney Chamber of Commerce, 36 Grosvenor-street, Sydney.

*ENGINEERING EXHIBITION.—Mon., July 4, to Sat., July 9, at Melbourne. Inquiries to the Industrial Public Relations Bureau of Australia, 259 Collins-street, Melbourne, Australia.

*CANADIAN PRAIRIE FAIRS.—Mon., July 4, to Sat., Aug. 6, at Brandon, Calgary, Edmonton, Regina and Saskatoon. Agricultural and dairy machinery exhibits. Apply to Exhibitions and Fairs Branch, Board of Trade, Lacon House, Theobalds-road, London, W.C.1.

PRINTING, MACHINERY AND ALLIED TRADES EXHIBITION (IPEX).—Tues., July 5, to Sat., July 16, at Olympia, London, W.14. Promoted by the Association of British Manufacturers of Printers' Machinery (Proprietary) Ltd., Clifford's Inn, London, E.C.4. Organisers: F. W. Bridges and Sons, Ltd., Grand Buildings, Trafalgar-square, London, W.C.2. Tel. WHItehall 0568.

*WESTERN PLANT MAINTENANCE AND ENGINEERING SHOW.—Tues., July 12, to Thurs., July 14, at the Pan Pacific Auditorium, Los Angeles, Calif. *Agents:* Clapp and Poliak Inc., 341 Madison-avenue, New York 17.

GREAT YORKSHIRE AGRICULTURAL SHOW.—Tues., July 12, to Thurs., July 14, at Harrogate, Yorkshire. Organised by the Yorkshire Agricultural Society, Cliftonfield, Shipton-road, York. Tel. York 3102.

NATURALLY-OCCURRING NITROGEN HETEROCYCLIC COMPOUNDS, SYMPOSIUM ON.—WED., July 13, to Fri., July 15, at the University College of the South West of England, Exeter. Organised by the Chemical Society, Burlington House, Piccadilly, London, W.1. Tel. REGent 0675. Apply to Dr. K. Schofield, Washington-Singer Laboratories, Prince of Wales-road, Exeter.

DRY CLEANING, DYEING AND ALLIED TRADES EXHIBITION.—Fri., July 15, to Sun., July 24, at the Ausstellungspark, Munich. Organised by the Internationale Fachausstellung Chemisch-Reinigung und Färberei, Geschäftsstelle, Munich 12, Germany.

WATER SUPPLY CONGRESS AND EXHIBITION (INTERNATIONAL).—Mon., July 18, to Sat., July 23, at Royal Horticultural Society's Halls, Vincent-square, London, S.W.1. Organised by the International Water Supply Association, 34 Park-street, London, W.1. Tel. GROsvenor 1092. See ENGINEERING, March 11, page 304.

*AMERICAN POULTRY AND HATCHERY FEDERATION'S ANNUAL CONVENTION.—Tues., July 19, to Fri., July 22, at St. Louis, Mo., U.S.A. Agricultural and dairy machinery exhibits. Apply to the Federation's offices, 521 East 53rd-street, Kansas City 10, Mo., U.S.A.

PURE AND APPLIED CHEMISTRY, INTERNATIONAL CONGRESS OF.—Thurs., July 21, to Wed., July 27, at Zürich. Organised by the International Union of Pure and Applied Chemistry, the 18th conference of which will be held, also at Zürich, from Wed., July 20, to Thurs., July 28. Apply to the Chemical Society, Burlington House, Piccadilly, London, W.1. Tel. REGent 0675.

SKANE (SWEDISH NATIONAL) FAIR (37TH).—Sat., July 23, to Sun., July 31, at Malmö. Organised by Skanemassan Kommissariat, Stora Nygatan 15, Malmö, Sweden.

AUSTRIAN INTERNATIONAL EXPORT AND TRADE FAIR.—Fri., July 29, to Sun., Aug. 7, at Dornbirn, Austria. Organised by Export-U Mustermesse G.m.b.H., Dornbirn. *Agents:* British Austrian Chamber of Commerce, 29 Dorset-square, London, N.W.1. Tel. PADdington 7646.

*AGRICULTURAL SHOW.—Sat., July 30, to Mon., Aug. 1, at Lusaka. Organised by the Northern Rhodesia Agricultural Society, Lusaka.

*ATOMIC ENERGY FOR INDUSTRIAL USE, EXHIBITION.—Mon., Aug. 8, to Sat., Aug. 20, at Geneva, under the sponsorship of the United Nations Organisation. Some six countries, including the United States, are expected to participate. Apply to the United Kingdom Atomic Energy Authority, 1-13 St. Giles High-street, London, W.C.2.

*ROYAL NATIONAL AGRICULTURAL AND INDUSTRIAL EXHIBITION.—Thurs., Aug. 11, to Sat., Aug. 20, at Brisbane. Organised by the Royal National Agricultural and Industrial Association, 99 Creek-street, Brisbane, Australia.

AUTOMOTIVE ENGINEERS, SOCIETY OF.—*West Coast Meeting:* Mon., Aug. 15, to Wed., Aug. 17, at Portland, Oregon. *Aircraft Production Forum and Aircraft Engineering Display:* Tues., Oct. 11, to Sat., Oct. 15, at Los Angeles. *Transportation Meeting:* Mon., Oct. 31, to Wed., Nov. 2, at St. Louis, Miss. *Diesel Engine Meeting:* Wed., Nov. 2, to Fri., Nov. 4. Apply to the Society of Automotive Engineers, 29 West 39th-street, New York, 18.

MATHEMATICAL COLLOQUIUM, BRITISH.—Tues., Sept. 6, to Thurs., Sept. 8, at Exeter. Apply to Secretary, 7th British Mathematical Colloquium, University College of the South-West of England, Exeter. Tel. Exeter 4141.

GAS SALES AND SERVICE CONFERENCE (FOURTH).—Mon., Sept. 12, to Wed., Sept. 14., at the Heads of Ayr Holiday Camp, Ayr, Scotland. Organised by the Gas Council, 1 Grosvenor-place, London, S.W.1. Tel. SLOane 4554. (Alteration of dates).

ELECTROMAGNETICALLY-ENRICHED ISOTOPES (CONFERENCE).—Tues., Sept. 13, to Fri., Sept. 16, at the Atomic Energy Research Establishment, Harwell, Berks. Tel. Abingdon 620. See ENGINEERING, March 11, page 321.

ELECTRICAL ENERGY CONGRESS.—Mon., Sept. 19, to Fri., Sept. 23, Church House, Dean's Yard, London, S.W.1. Tenth congress of the International Union of Producers and Distributors of Electricity (UNIPEDE). Apply to the Public Relations Officer, British Electricity Authority, Winsley-street, London, W.1, Tel. MUSeum 4040; or to the Information Department, North of Scotland Hydro-Electric Board, 16 Rothesay-terrace, Edinburgh, 3. Tel. Edinburgh Central 1361. See ENGINEERING, January 21, page 71.

*ROYAL AGRICULTURAL SHOW.—Thurs., Sept. 22, to Sat., Oct. 1, at Melbourne. Organised by the Royal Agricultural Society of Victoria, Melbourne.

*NATIONAL SMOKE ABATEMENT SOCIETY'S ANNUAL CONFERENCE.—Wed., Sept. 28, to Fri., Sept. 30, at Bournemouth. Apply to Society's offices: Palace Chambers, Bridge-street, London, S.W.1. Tel. TRAfalgar 6836.

*ROYAL AGRICULTURAL SHOW.—Sat., Oct. 1, to Thurs., Oct. 6, at Claremont, Western Australia. Organised by the Royal Agricultural Society of Western Australia, 9 Howard-street, Perth.

*METALS EXPOSITION (37TH NATIONAL).—Mon., Oct. 17, to Fri., Oct. 21, at Detroit. Organised by the American Society for Metals, 7301 Euclid-avenue, Cleveland 3, Ohio, U.S.A.

*CANADIAN INDUSTRIAL TOOL AND EQUIPMENT SHOW.—Mon., Oct. 24, to Fri., Oct. 28, at the Show Mart Building, Montreal. Inquiries to the show offices: 4585 Sherbrooke-street W., Montreal.

*ROYAL AGRICULTURAL WINTER FAIR.—Fri., Nov. 11, to Sat., Nov. 19, at Toronto. Organised by the Royal Winter Fair Authorities, Royal Coliseum, Exhibition Park, Toronto 2B, Canada.

BUILDING EXHIBITION (26TH).—Wed., Nov. 16, to Wed., Nov. 30, at Olympia, London, W.14. Apply to the Building Trades Exhibition, 4 Vernon-place, London, W.C.1. Tel. CHAncery 2223.

A PREFABRICATED STEELWORK TECHNIQUE FOR BUILDINGS

Advantages of Cold-rolled Sections

Since the end of the war a number of techniques have been developed for the more rapid construction of buildings. In particular, the methods have been applicable and especially successful for single-storey buildings of many spans, involving much repetition and covering a large floor area. Among the largest is a storage building, now nearing completion, with a floor space of more than three-quarters of a million square feet that has been designed and largely prefabricated by Metal Sections, Limited, Oldbury, Birmingham, a subsidiary of Tube Investments, Limited.

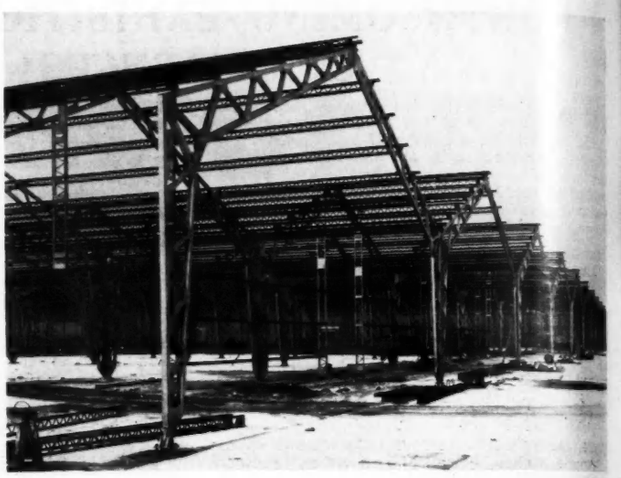
The basic principle of the method of construction—the prefabrication of parts by cold-roll forming of steel strip—has been used by the company for a number of years for building the skeleton frames of buses, coaches and railcars, and the extension of the method to the manufacture of structural members has proved a natural development.

Using 12 or 14-gauge steel, the strips are cold-roll formed into open-box or near-tube sections and the resulting sections have many properties, both mechanical and aesthetic, approaching those of tubes. In particular, together with tubes, they have the advantage over the conventional hot-rolled sections of greater variation in size and the greater ease with which they can be stiffened and strengthened locally by the addition of extra material spot welded into place. As for tubes, the cold-roll sections are claimed to effect up to as much as a 30 per cent. saving of steel weight for a given structure. The general appearance of the new building, shown in the illustration above, has many of the distinctive features of lightness and cleanness possessed by modern tubular structures, but the initial cost of the cold-rolled section is claimed to be much less than that of the drawn tube. Considered in detail, however, the open sections used would not appear to be so corrosion-proof as the full-tube section, but the design has ensured that all members are inclined to the horizontal so reducing any tendency for moisture to be trapped within the sections. Resistance to corrosion has also been obtained by using " Corten " steel, a high-tensile strength chromium-molybdenum alloy which is claimed to have a corrosion resistance of between four and six times that of ordinary mild steel. In addition, of course, the steelwork is degreased, phosphated and treated with zinc-rich or aluminium paints. At critical positions, such as at points of contact with the foundations, heavy grey-iron castings have been provided.

Particular features of the building are the three-pinned structural frame and the design of the roof. The main frame is based on a three-pin portal frame constructed of four shop-made members, namely, the two legs and the two roof beams which are bolted at the shoulders to make the two easily-erected half-sections of the portal frame; the three-pinned frame has a particular advantage in that it can, without damage, take up any small discrepancies in the layout of the foundations. Purlins and cross bracing are used in a conventional manner to obtain longitudinal stability of the structure.

The second notable feature is the method adopted for attaching the lining and insulating panels to the framework. A composite roof member spans between the purlins and this is shaped to receive the lining boards with the insulated blanket already stapled to them. These boards are dropped into position from outside the building by the same gangs who are fitting the external cladding, so eliminating the use of interior scaffolding. The internal boards are held in position by a simple metal clip.

The general contractor has been Sir Alfred McAlpine and Son, Limited, Little Sutton, and during 14 months they have cleared the site and laid 15,500 cub. yd. of concrete in the foundations and floor slabs. In the same time Metal Sections, Limited, have fabricated 1,400 tons of steelwork in the form of over 2,000,000 linear feet of various cold-rolled sections and that, when the building is finished, the sheeters will have erected nearby 900,000 sq. ft. of asbestos-cement cladding and a similar amount of both lining board and insulation blanket. A third feature to be noted is that the roof drainage has been achieved by building on a falling site and providing large-section valley gutters with large-diameter down pipes only at the end of the sheds, thereby eliminating many drainage runs along the lines of the foundations.



The basis of this structure is a three-pinned portal frame erected with four shop-made members fabricated from cold-rolled sections mainly of 12 or 14 gauge steel. The leg and rafter are site bolted at the shoulder. Both the lining and the cladding of the double skin roof are erected from the outside.

NOTICES OF MEETINGS

Association of Supervising Electrical Engineers

BOURNEMOUTH
Annual General Meeting. Bournemouth Branch. Grand Hotel, Bournemouth. Mon., May 30, 7.15 p.m.

BRISTOL
Annual General Meeting. Bristol and West of England Branch. Grand Hotel, Bristol. Fri., June 3, 7.30 p.m.

CROYDON
Annual General Meeting. South London Branch. Café Royal, North End, Croydon. Thurs., June 2, 7.15 p.m.

LIVERPOOL
Annual General Meeting. Liverpool Branch. Liverpool Engineering Society, 9 The Temple, 24 Dale-street, Liverpool. Fri., June 3, 6.30 p.m.

PRESTON
Annual General Meeting. Preston Branch. Preston Chamber of Commerce, 49A Fishergate, Preston. Wed., June 1, 7.30 p.m.

WEMBLEY
Annual General Meeting. North-West London Branch. Century Hotel, Forty-avenue, Wembley Park. Fri., June 1, June 1, 7.30 p.m.

Chemical Engineering Group

LONDON
Annual General Meeting. Café Royal, Regent-street, W.1. Fri., June 3, 6.15 p.m. (To be followed by the annual dinner.)

Chemical Society

LONDON
Centenary Lecture on " Chemical Effects of Steric Strains." by Professor H. Brown. Thurs., June 2, 7.30 p.m.

OXFORD
Lecture by Sir Robert Robinson, O.M. Oxford Branch. Physical Chemistry Laboratory, South Parks-road, Oxford. Wed., June 6, 8.15 p.m.

Incorporated Plant Engineers

LONDON
Discussion on " Work Study." London Branch. Royal Society of Arts, John Adam-street, Adelphi, W.C.2. Tues., June 7, 7 p.m.

LIVERPOOL
" Liquid-Fuel Firing," by S. S. Whitehead. Merseyside and North Wales Branch. Royal Institution, Colquitt-street, Liverpool. Thurs., June 16, 7.15 p.m.

MANCHESTER
Open Meeting. Manchester Branch. Engineers' Club, Albert-square, Manchester. Tues, June 7, 7.15 p.m.

NEWCASTLE-UPON-TYNE
" Steam for Process," by L. G. Northcroft. North-East Branch. Roadway House, Oxford-street, Newcastle-upon-Tyne. Thurs., June 9, 7 p.m.

Institute of Physics

GLASGOW
Summer Meeting, Non-Destructive Testing Group, Royal Technical College, Glasgow. Wed., June 22, to Sat., June 25. Assembly, Wed., June 22, 8 p.m.
Annual General Meeting; " Training for Radiography," by T. S. Wylie; " Shipyard Radiography," by E. J. Duffy; and " Non-Destructive Testing in the Boilermaking Industry," by W. G. Marskell, at 9 a.m. " Surface Properties: Their Possible Use in the Testing of Materials," by Dr. R. W. B. Stephens; and " The Physical Meaning of Indentation and Scratch Hardness," by Dr. D. Tabor, at 2.15 p.m. Supper at 7.15 p.m., Thurs., June 23.
" An Assessment of Ultrasonic Techniques, with Special Reference to Welds," by H. L. Carson; and " Problems in the Interpretation of Ultrasonic Tests on Steel," by I. M. MacKenzie and R. Kennedy, at 9.15 a.m. Works Visits and Evening Excursion, from 1.30 p.m. onwards, Fri., June 24.
" Neutron Radiography," by Dr. J. Thewlis and R. T. P Derbyshire; and Discussion on " Research Work Required to Promote Progress in the Field of Non-Destructive Testing," opened with a paper on " The Scope of Non-Destructive Testing," by Dr. E. G. Stanford. Sat., June 25, 9.30 a.m.

Institution of Civil Engineers

LONDON
Annual General Meeting. Corporate members only. Tues., June 7, 5.30 p.m.

Institution of Mining Engineers

EDINBURGH
Summer Meeting. Royal Society of Edinburgh, 24 George-street, Edinburgh. Wed., Thurs. and Fri., June 15 to 17.
" Physico-Chemical Studies on Dust: Some Factors Controlling the Formation of Aqueous Sprays for the Control of Dusts; Some Factors Controlling the Rate of Sedimentation of Airborne Dusts," by W. Gibb., W. Glen, Professor G. Hibberd and Professor P. D. Ritchie, at the morning session.
" The Construction of New Collieries in Scotland," by H. R. King, at the afternoon session, Wed., June 15.
Various visits and excursions, Thurs. and Fri., June 16 and 17.

Institution of Mining and Metallurgy

LONDON
" Application of Plastic Igniter Cord to Blasting Operations in Metalliferous Mines," by R. Haslam, R. D. J. Owens and J. Hancock; and " Concealed Lead-Zinc Fields in England," by Dr. G. A. Schnellmann. Apartments of the Geological Society, Burlington House, Piccadilly, W.1. Thurs., June 16, 5 p.m.

Institution of Naval Architects

LONDON
" The Influence of Dimensions on the Behaviour of Partial Superstructure," by W. Muckle; and " The Strength of Corrugated Plating for Ships' Bulkheads," by J. B. Caldwell. Thurs., June 9, 4.45 p.m.

Royal Institution

LONDON
" Weather Forecasting: The Future Outlook," by Sir Graham Sutton. Fri., June 10, 9 p.m.

The Royal Society

LONDON
Discussion on " Radiative Balance in the Atmosphere," to be opened by H. W. S. Massey. Thurs., June 9, 11 a.m.

Women's Engineering Society

MANCHESTER
Annual General Meeting and Film Evening. Manchester Branch. Engineers' Club, Albert-square, Manchester, 2. Wed., June 8, 6.45 p.m.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than Monday morning in the week preceding the date of the meeting.

Association of Supervising Electrical Engineers, 23 Bloomsbury-square, London, W.C.1. (LANgham 5927.)
Chemical Engineering Group, 56 Victoria-street, London, S.W.1. (VICtoria 6161.)
Chemical Society, Burlington House, Piccadilly, London, W.1. (REGent 0675.)
Incorporated Plant Engineers, 48 Drury-lane, Solihull, Birmingham. (Solihull 3021.)
Institute of Physics, 47 Belgrave-square, London, S.W.1. (SLOane 9806.)
Institution of Civil Engineers, Great George-street, London, S.W.1. (WHIthall 4577.)
Institution of Mining Engineers, Salisbury House, Finsbury-circus, London, E.C.2. (NATional 0624.)
Institution of Mining and Metallurgy, Salisbury House, Finsbury-circus, London, E.C.2. (NATional 0621.)
Institution of Naval Architects, 10 Upper Belgrave-street, London, S.W.1. (SLOane 4622.)
Royal Institution, 21 Albemarle-street, London, W.1. (HYDe Park 0669.)
Royal Society, Burlington House, Piccadilly, London, W.1. (REGent 3335.)
Women's Engineering Society, 45 Eastcastle-street, London, W.1. (LANgham 9571.)